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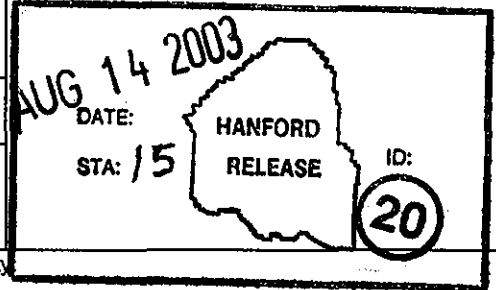
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618-10 and 618-11 Waste Burial Grounds Basis for Interim Operation

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

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Contractor for the U.S. Department of Energy
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618-10 and 618-11 Waste Burial Grounds Basis for Interim Operation

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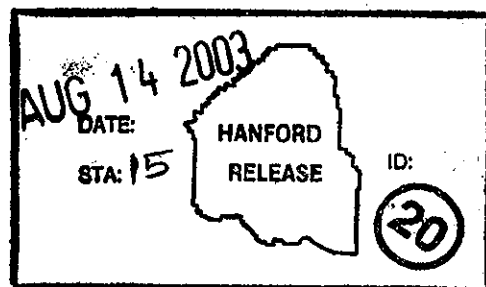
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Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

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**618-10 and 618-11
Waste Burial Grounds
Basis For Interim Operation**

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EXECUTIVE SUMMARY

The purpose of this Basis for Interim Operation is to systematically identify and analyze the hazards associated with surveillance, characterization, and groundwater monitoring within the 618-10 and 618-11 Waste Burial Grounds on the U.S. Department of Energy Hanford Site. The Basis for Interim Operation for the 618-10 and 618-11 Waste Burial Grounds and its associated technical safety requirements establish the safety basis for the 618-10 and 618-11 Waste Burial Grounds.

The 618-10 Waste Burial Ground is located approximately 4.3 mi (6.9 km) northwest of the Hanford Site 300 Area and received low- to high-activity waste, fission products, and some plutonium-contaminated waste from March 1953 until September 1963. The 618-11 Waste Burial Ground is located approximately 7.3 mi (11.7 km) northwest of the Hanford Site 300 Area (west of Energy Northwest's Columbia Generating Station) and received low- to high-activity waste, fission products, plutonium, and other transuranic constituents from October 1962 until December 1967. The waste received at both sites was from the 300 Area.

This Basis for Interim Operation documents the safety basis for surveillance, characterization, and groundwater monitoring activities in the 618-10 and 618-11 Waste Burial Grounds and is being released as a Fluor Hanford, Inc., engineering document to establish the safety basis for the work scope described in this Basis for Interim Operation for the 618-10 and 618-11 Waste Burial Grounds.

The Basis for Interim Operation was prepared using a graded application of requirements and guidance for facilities that are in long-term surveillance and maintenance while conducting deactivation, decontamination, and decommissioning activities, as stated in DOE-STD-3011-2002, *Guidance for Preparation of Basis for Interim Operation (BIO) Documents*. This format was used based on the requirements in 10 CFR 830, "Nuclear Safety Management," Subpart B, "Safety Basis Requirements," Table 2.

The Basis for Interim Operation includes a description of the hazards associated with surveillance, characterization, and groundwater monitoring activities for the 618-10 and 618-11 Waste Burial Grounds. This document also describes the measures taken to eliminate, control, or mitigate these hazards, and the analysis and evaluation of potential accidents and their associated risks. DOE-STD-1027-92, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23 Nuclear Safety Analysis Reports*, also was used in the preparation of this Basis for Interim Operation.

Hazards and accident analyses were performed to identify radiological and chemical hazards as well as energy sources with the potential to initiate, or contribute to, uncontrolled releases of hazardous material. The hazards associated with the 618-10 and 618-11 Waste Burial Grounds work scope were identified utilizing the Site standardized hazard source checklist. The hazard evaluation identified two categories of accidents: fire and inadvertently exhumed waste. Based upon the evaluation of these hazards, accidents were selected for more detailed analysis. The following accidents are analyzed in this Basis for Interim Operation:

- Caisson waste penetration
- Caisson penetration with fire
- Release of contaminated soil
- Sample pit accident.

Analyses of representative accidents were performed by evaluating an unmitigated condition in which no credit was taken for existing engineered or administrative controls. The accident frequencies were estimated and radiological dose consequences to the offsite public and the onsite worker were determined. The unmitigated radiological dose consequences combined with the estimated frequencies were compared with the established risk evaluation guidelines to determine the need for safety-related structures, systems, or components. Administrative controls were then assigned, as necessary, to reduce the overall risk.

Technical safety requirements are based upon the analyses and principal assumptions presented in the Basis for Interim Operation. The control set derived for each accident scenario identifies preventive and mitigative features that are credited to reduce the risk of the scenario for the

offsite public and the maximum onsite worker. The control set for the 618-10 and 618-11 Waste Burial Grounds defines the operating limits, surveillance requirements, administrative controls, and design features necessary to protect the health and safety of the offsite public and onsite worker, and to minimize the risk to facility workers from uncontrolled release of radioactive or other hazardous material. The control set consists of the following Administrative Controls:

- Administrative Controls
 - Organization and management
 - Emergency preparedness

Safety management programs provide formal, disciplined methods of operations at the Hanford Site, which includes the 618-10 and 618-11 Waste Burial Grounds. Implementation of safety management programs minimizes the potential for harm to workers and minimizes the chances of potential accidents that could impact the public, workers, and the environment. The safety management program commitments and the administrative controls in the technical safety requirements adequately protect the offsite public and onsite worker and minimize the risk to facility workers from currently authorized activities at the sites. Vulnerabilities are limited to the uncertainties associated with the characterization and monitoring activities and are controlled through the safety management program and the unreviewed safety question process by identifying any activities outside of the safety basis that may require further analysis.

The final Hazards Categorization was determined based on the accident analysis. The 618-10 Waste Burial Ground remains a Hazards Category 3 site, and the 618-11 Waste Burial Ground is also a Hazards Category 3 site.

Analyses presented in the Basis for Interim Operation demonstrate that surveillance, characterization, including planned caisson and vertical pipe unit penetrations and groundwater monitoring, of the 618-10 and 618-11 Waste Burial Grounds do not present undue risk.

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ACRONYMS AND ABBREVIATIONS

ARF	airborne release fraction
BIO	Basis for Interim Operation
CFR	<i>Code of Federal Regulations</i>
CP	Central Plateau Remediation Project
DR	damage ratio
DCF	dose conversion factor
DOE	U.S. Department of Energy
ERPG	emergency response planning guideline
LPF	leak path factor
MAR	material at risk
RF	respirable fraction
SMP	Safety Management Program
SSC	Structures, systems, and components
TEDE	total effective dose equivalent
TEEL	temporary emergency exposure limit
TSR	Technical Safety Requirement
VPU	vertical pipe unit
χ/Q	atmospheric dispersion (seconds per meters cubed)
EMI	electromagnetic induction

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1.0 INTRODUCTION

This Basis for Interim Operation (BIO) documents the safety basis for the 618-10 and 618-11 Waste Burial Grounds (referred to in this document collectively as the 618-10 and 618-11 sites or individually as the 618-10 site or the 618-11 site). The principal U.S. Department of Energy (DOE) documents used in the preparation of this document include DOE-STD-3011-2002, *Guidance for Preparation of Basis for Interim Operation (BIO) Documents*, and DOE-STD-1027-92, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports*. DOE-STD-3011-2002 refers to the use of DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analysis*, in preparing a BIO. DOE-STD-3011-2002 is an appropriate documented safety analysis guideline for DOE nuclear facilities that are not operating or for facilities during deactivation, decommissioning, and decontamination when the predominant operation is surveillance and maintenance. Therefore, developing the BIO in accordance with this standard meets the requirements for a documented safety analysis in 10 CFR 830, "Nuclear Safety Management," Subpart B, "Safety Basis Requirements," Section 830.204, "Documented Safety Basis." Governing Project Hanford Management Contract procedures also were used during the preparation of this BIO.

This BIO and companion technical safety requirements (TSR) will serve as the safety basis during surveillance, characterization, and groundwater monitoring activities at the 618-10 and 618-11 sites.

1.1 BACKGROUND

The 618-10 site, also referred to as the 300 Area North or 300 Area North Burial Ground, is located 4.3 mi (6.9 km) north of the Hanford Site 300 Area. The site received radioactive waste from the 300 Area laboratories and facilities from 1953 to 1963. The 618-10 site is approximately 485 ft by 570 ft (148 m by 174 m); it contains 12 burial trenches and 94 vertical pipe units (VPU).

The 618-11 site, also referred to as the Wye Burial Ground or "Y" Burial Ground, is located 7.3 mi (9.7 km) north of the 300 Area. The site received radioactive waste from the 300 Area laboratories and facilities from 1962 to 1967. The 618-11 site is approximately 375 ft by 1,000 ft and contains 3 back-filled trenches (50 ft by 900 ft [15 m by 270 m]), 50 vertical pipe storage units, and up to 5 caisson storage units (8 ft in diameter by 10 ft high).

1.2 PURPOSE

This BIO documents the safety basis for surveillance, characterization, and groundwater monitoring activities in the 618-10 and 618-11 sites. It also provides the hazard and accident analyses from which the control set is derived and provides the bases for reviewing future activities through the unreviewed safety question process.

1.3 SCOPE

The scope of this BIO for the 618-10 and 618-11 sites is to evaluate the activities described in the following chapters and determine the appropriate controls to protect the public, onsite worker, and the environment. Activities currently conducted at the sites are limited to nonintrusive monitoring and surveillance. To prepare for restoration of the sites, characterization activities will be required to assist in planning removal of the materials. Proposed changes to the activities described and analyzed in this BIO will be evaluated in accordance with the unreviewed safety question process to identify any hazards and to determine the approval authority for the change.

This BIO documents the facility design, develops the operational safety envelope, and establishes the bases for the TSRs. The BIO also contains sufficient information on safety management programs (SMP), safety analysis, and operational controls to adequately document the basis for the safe operation of the facility. The BIO and TSRs establish the safe operating envelope for the facility worker, maximum onsite individual, public, and protection of the environment. The control and monitoring of airborne and liquid effluents to the environment will be addressed in the appropriate type of permits required to complete the scope of work defined in Chapter 2. The SMP is described in Section 5.6.

1.4 ORGANIZATION AND CONTENT OF BASIS OF INTERIM OPERATION

This section summarizes the information that will be found in each chapter of the BIO.

1.4.1 Executive Summary

The Executive Summary provides high-level summary discussions of the significant conclusions in the BIO. Background material provided includes a brief description of the facility mission and an overview of the safety analysis. Significant aspects of facility management and safety management are summarized.

1.4.2 Chapter 1, Introduction

Chapter 1 provides the purpose and scope of the BIO. This chapter also outlines the organization and content of the 618-10 and 618-11 site BIO, presents the hazard category for the 618-10 and 618-11 sites, and provides a brief history the 618-10 and 618-11 sites.

1.4.3 Chapter 2, Waste Site Descriptions

Chapter 2 describes the sites and provides relevant operational histories. Information on structures, systems, and components (SSC) is included. Sufficient background material is provided to enable the reader to understand the major site elements assumed to exist in the hazard and accident analyses.

1.4.4 Chapter 3, Hazards and Accident Analysis

Chapter 3 describes the methodology for and approach to hazards and accident analysis. This chapter defines the hazardous materials and energy sources anticipated at the 618-10 and 618-11 sites and the results of the hazards and accident analysis.

1.4.5 Chapter 4, Safety Structures, Systems, and Components

Chapter 4 describes the safety classified SSCs including their safety functions. This chapter includes a description of the support systems required to operate and maintain the safety SSCs.

1.4.6 Chapter 5, Derivation of Technical Safety Requirements

Chapter 5 presents information useful in linking the BIO to the TSR document, such as the basis of safety limits and controls, and a listing of TSR design features and their rationales. This chapter also identifies the programmatic approach to safety management for the workers at the 618-10 and 618-11 sites and for the general public.

1.4.7 Chapter 6, Prevention of Inadvertent Criticality

Chapter 6 describes the criticality safety program. The program ensures that operations with fissile material remain subcritical under all normal and credible abnormal conditions.

1.4.8 Chapter 7, References

Chapter 7 provides a list of the references used in preparing this document.

1.5 HAZARD CATEGORIZATION SUMMARY

The initial hazard categorization for the 618-10 site was Hazard Category 3, and for the 618-11 site, it was Hazard Category 2. This designation was based on the estimated inventory at the sites and documented in the calculation provided in Appendix A. The final hazard category for each site was determined after the accident analysis was prepared. The inventory used for the accident analysis was based on the maximum plutonium content at the 618-11 site (as described in the calculation in Appendix A). Based on the accident analysis in Section 3.6, the final hazards category for the 618-10 site remains a Hazards Category 3 and the final hazards category for the 618-11 site also is Hazards Category 3.

1.6 SAFETY BASIS HISTORY

The 618-10 and 618-11 sites do not currently have a safety basis. The sites are inactive and considered low risk due to the scope of activities performed at the sites, which is surveillance only. The work scope defined in this BIO includes characterization to prepare for removal and disposal of the buried waste.

The 618-10 and 618-11 sites are captured in *Record of Decision for Hanford 300-FF-2 Operable Unit* (Goldstein 2001). The Record of Decision presents the recommended interim remedial

actions for the 618-10 and 618-11 sites. These actions are based on evaluation of hazards associated with cleaning up the sites, protection of human health and the environment, and anticipated future land use in this area. This BIO will provide the initial safety basis to support surveillance, characterization, and groundwater monitoring.

2.0 WASTE SITES DESCRIPTION

2.1 BACKGROUND

The 618-10 Waste Burial Ground, also known as 300 North, 300 North Burial Ground, or 318-10 Waste Site, is located about 4.3 mi (6.9 km) northwest of the 300 Area. The 618-11 Waste Burial Ground, also known as the Wye Burial Ground or 318-11, is located directly west of Energy Northwest's Columbia Generating Station. See Figure 2-1 for a map of the Hanford Site showing the locations of the 618-10 and 618-11 sites. The sites received low- to high-activity radioactive waste from the 300 Area laboratories and fuels development facilities. The 618-10 site was operated from March 1953 until September 1963, and the 618-11 site was operated from March 1962 until December 1967.

During the years that the 618-10 and 618-11 sites were active, disposal records did not include an inventory of waste content. Transuranic-contaminated waste was not separately regulated or segregated from the other waste types transported to the disposal sites. Some of the waste that was disposed of in trenches, VPUs, and caissons would be designated transuranic waste by current criteria.

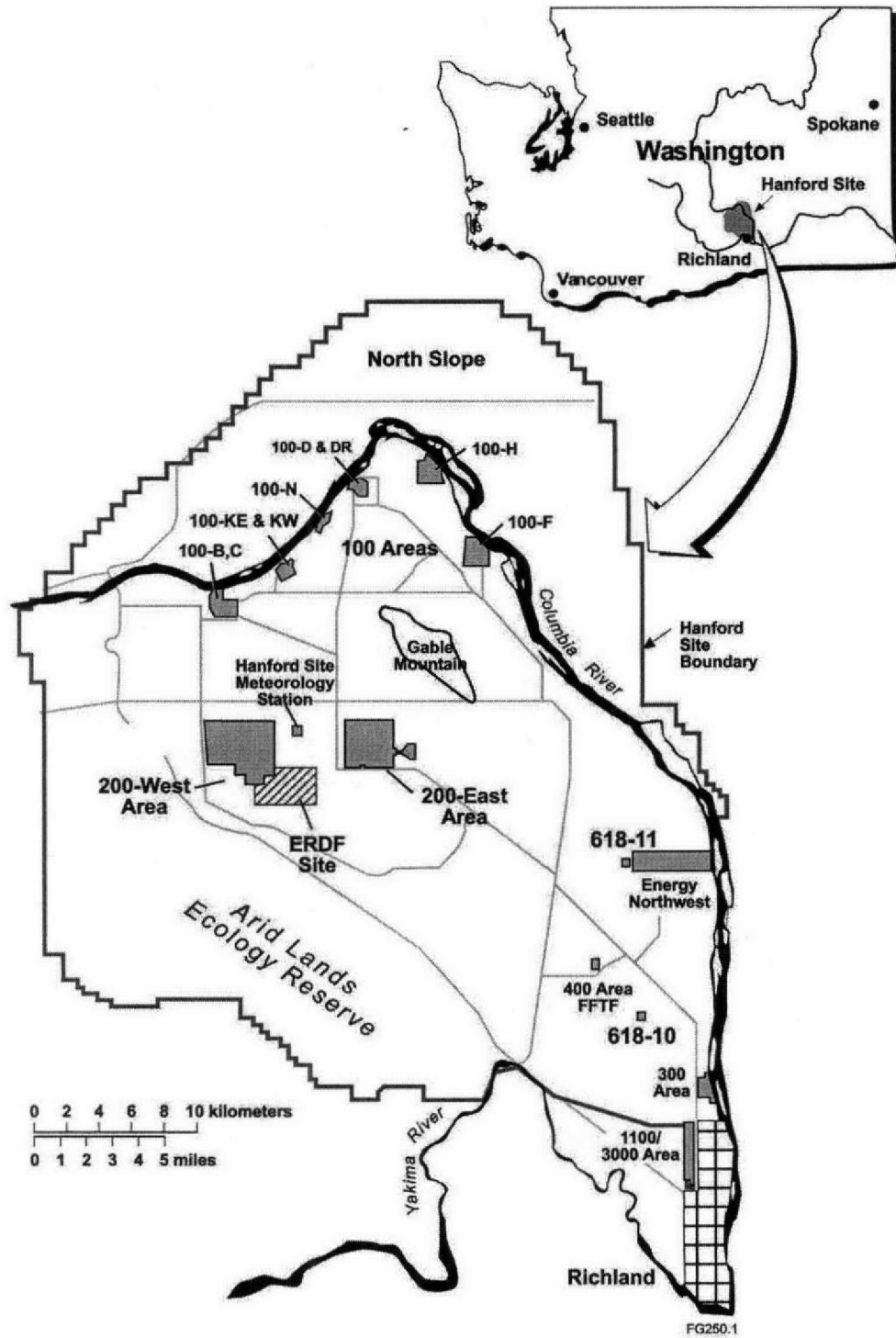
The burial grounds have been surface stabilized with an additional 2 ft of topsoil and vegetated with crested wheat grass. They are inside a chain link fence and posted with Underground Radioactive Material signs.

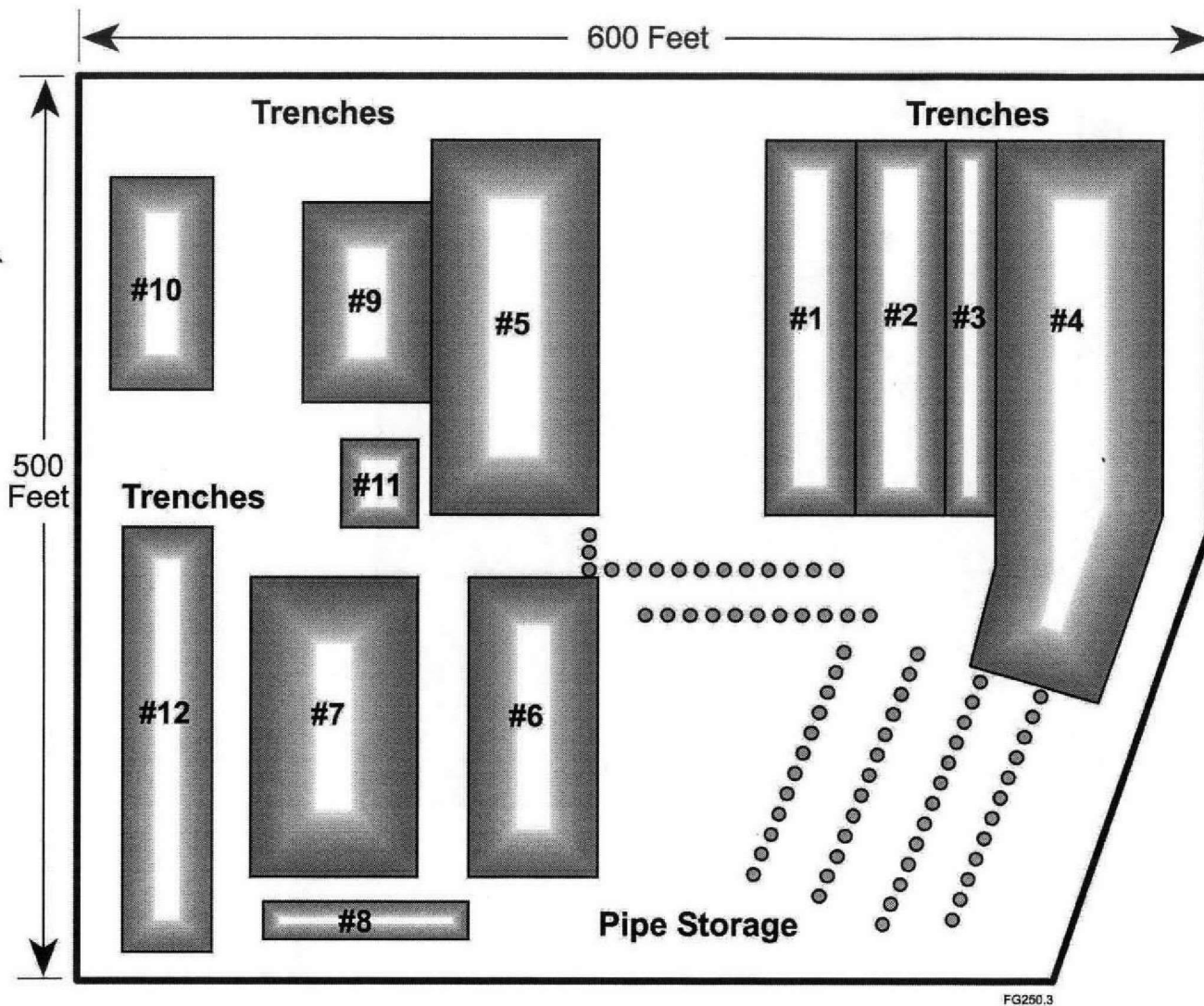
Current characterization activities are limited to nonintrusive surveys, such as surface radiological surveys and geophysical scans. The proposed work scope will include intrusive characterization activities that will provide definitive contaminant information needed to facilitate cleanup strategies. Planning for the remediation requires additional understanding of the quantity and condition of the material that was deposited in the waste sites. Therefore, characterization activities are required prior to initiation of remediation activities at the 618-10 and 618-11 sites.

2.2 THE 618-10 SITE

The 618-10 site consists of 12 trenches and 94 VPUs, as shown in Figure 2-2. The trenches range in size from 320 ft (97 m) long by 70 ft (21 m) wide by 25 ft (7.6 m) deep to 50 ft (15 m) long by 40 ft (12 m) wide by 25 ft (7.6 m) deep. The VPUs are 22-in.- (56-cm-) diameter, 15-ft- (4.6-m-) long waste receptacles constructed by welding five 55-gallon bottomless drums together end-to-end and burying them vertically (see Figure 2-3). The burial site was covered in soil when it was closed. Records do not indicate the exact amount of soil, but it is assumed to be 2 ft (0.6 m), which is the same amount used at the 618-11 site. An additional 2 ft (0.6 m) of topsoil was added to the site for surface stabilization in 1983.

Figure 2-1. Location of the 618-10 and 618-11 Waste Burial Grounds.

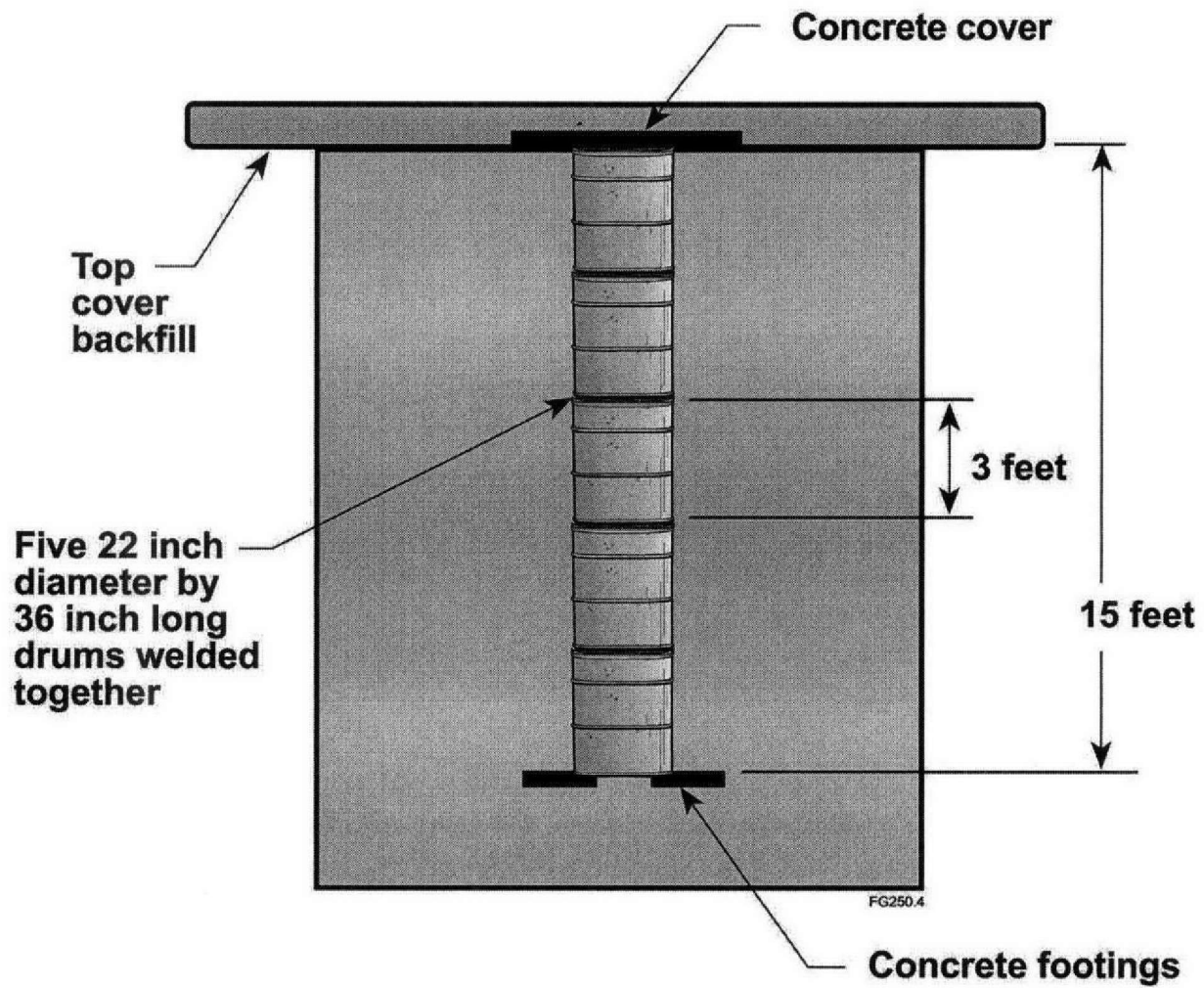




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Figure 2-2. The 618-10 Waste Burial Ground.

Figure 2-3. A 618-10 and 618-11 Site Vertical Pipe Unit.



2.2.1 Relevant Operating History

An estimated 4,800 to 7,400 yd³ (3,680 m³ to 5,670 m³) of material was buried at the 618-10 site, approximately 11 yd³ (8.4 m³) of which are equivalent to remote-handled transuranic waste. Radiological and chemical hazards include cesium, strontium, plutonium, americium, neptunium, beryllium, uranium, zirconium, and sodium-potassium metals.

Limited records were kept of the disposal practices, but approximately 40 boxes of records have been examined, which produced two file drawers full of files. Wastes received were generated mostly by the 308, 321, 325, 326, 327, 328, 329, 3211, 3707, 3741, and 3746 Buildings. Most of the waste resulted from 300 Area laboratory facilities. Wastes included radiological contaminated laboratory instruments, bottles, boxes, filters, aluminum cuttings, irradiated fuel element samples, metallurgical samples, electrical equipment, lighting fixtures, barrels, laboratory equipment and hoods, and low- and high-level liquid waste sealed in containers.

The exteriors of the waste containers were surveyed before the containers were transported to the 618-10 site. The actual contents of the containers are uncertain, but radiological survey records indicate the number of waste shipments and the types of containers used. Trenches generally received low-level waste in cardboard boxes. Materials with higher radioactivity were packaged in cement barrels (concrete and lead-shielded drums). From the mid-1950s to about 1960, radioactive wastes were packaged in cardboard containers and stored in lead pans referred to as "gunk catchers." Contaminated materials were often carried to the burial ground in "load luggers," which could hold approximately 200 ft³ of loose waste. Around 1960, the radioactivity of the waste disposed of from the 325 and 327 Laboratory hot cells increased due to the examination of fuel rod and tank waste samples. Cardboard containers and gunk catchers were replaced with remote-handled milk pails, paint cans, and juice cans. The containers were remotely loaded into lead-shielded casks for transport to the burial grounds. The waste was remotely released from the cask to the VPUs.

The 618-10 site stopped receiving waste in September 1963 and was surface stabilized with 2 ft (0.6 m) of clean backfill material in 1983.

2.2.2 Significant Abnormal Occurrences (Unplanned Releases)

The 618-10 site had three documented unplanned releases during operation of the burial site and one unplanned release during the addition of soil in 1983. The first release occurred in 1961 and was caused by a fire in a trench. The fire destroyed all flammable material in the affected trench including approximately 200 boxes of contaminated material and several high-efficiency particulate air filter-type cooling water system filters. Contamination was spread at a distance of 50 ft to 70 ft outside the fenced area. The trench was covered with dirt after the fire was extinguished.

The second release occurred in 1963 and involved a truck driver who was found to be contaminated after completing a burial of "milk cans" at the 618-10 site. Traffic was diverted to allow Environmental Monitoring to survey the road for possible contamination. The survey of the road between the burial ground and the 327 Building found one spot of contamination in

front of the 300 Area Powerhouse. No contamination was found on the highway. An area in front of the burial ground gate was contaminated and a 5-ft (1.5-m) radius around the VPU was contaminated.

The third release, also in 1963, resulted from the use of an improperly sealed container being dropped into a VPU. The lid came off the container causing a spread of contamination measuring approximately 600 ft² around the VPU.

After each release, the ground was either washed down using fire trucks or gravel was spread over the contaminated area to prevent the spread of contamination.

The last incident at the 618-10 burial site occurred during the addition of soil used to stabilize the area. During the soil moving operation, a truck drove over a trench area and what appeared to be oil came to the surface. The approximately 100 ft² of oil was found to be contaminated, with levels to 10,000 counts/min.

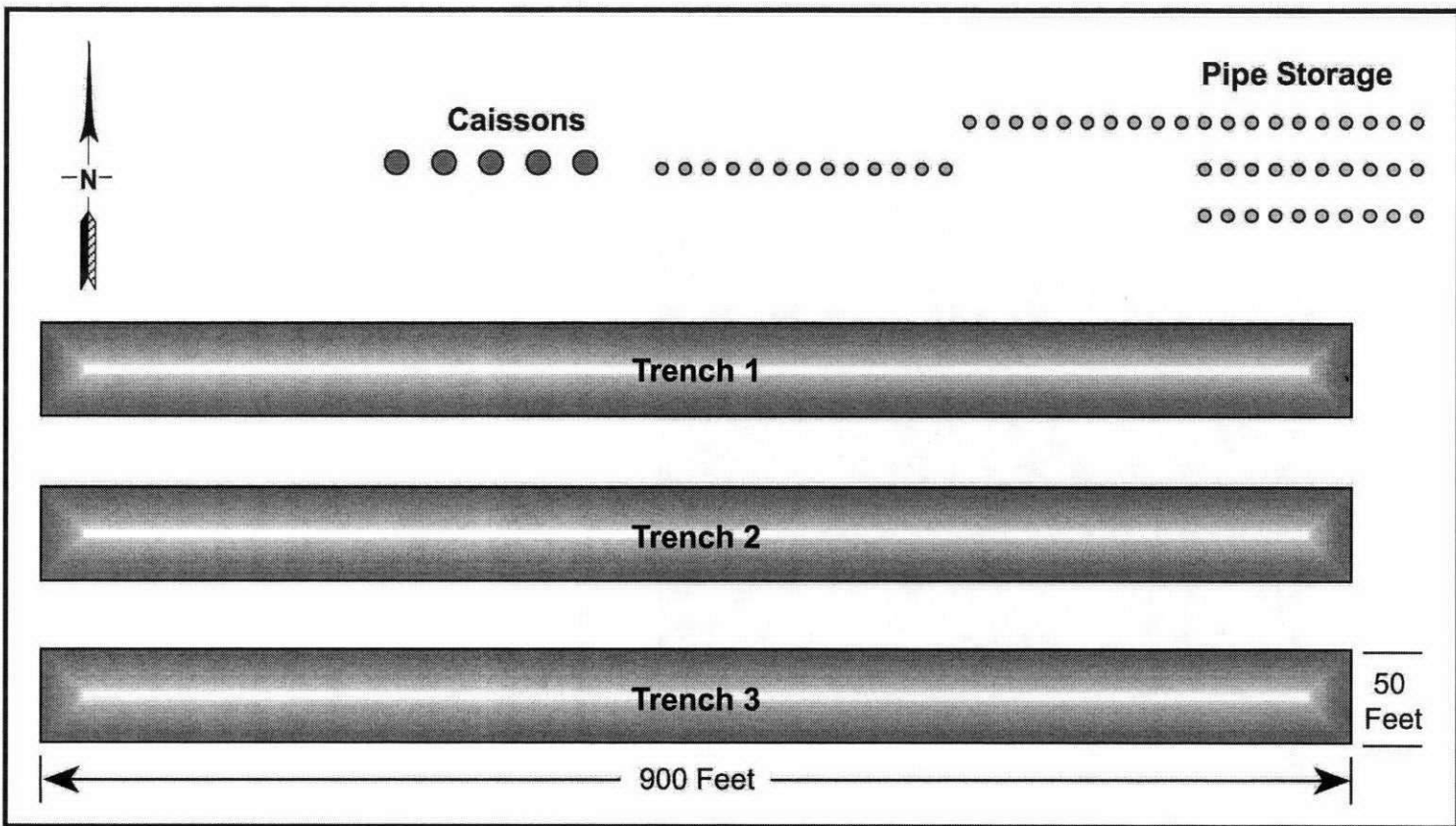
2.3 THE 618-11 SITE

The 618-11 site consists of 3 slope sided trenches, 3 to 5 large caissons, and 50 VPUs. See Figure 2-4 for a schematic drawing of the site. The trenches are 900 ft (270 m) long by 50 ft (15 m) wide and 25 ft (7.6 m) deep. The 50 VPUs are 22-in.- (56-cm-) diameter, 15-ft- (4.6-m-) long waste receptacles constructed by welding five 55-gallon bottomless drums together and burying them vertically with approximately 10 ft of spacing between the units (see Figure 2-3). The units are open to the soil at the bottom. The large-diameter caissons were constructed of 8-ft- (2.4-m-) diameter corrugated metal pipe, 10 ft (3 m) long, with the top of the caisson being 15 ft (4.6 m) below grade, and connected to the surface by an offset 36-in.- (91-cm-) diameter pipe with a dome cap lid (see Figure 2-5). These units were buried with approximately 15 ft of space between them. The caissons were open to the soil at the bottom. The number of caissons is questionable due to contradiction in site documentation. The burial ground received a minimum of 2 ft (0.6 m) of soil when it was closed. This was in addition to the soil cover used to close the trenches. An additional 2 ft (0.6 m) of topsoil was added to the site for surface stabilization in 1983.

2.3.1 Relevant Operating History

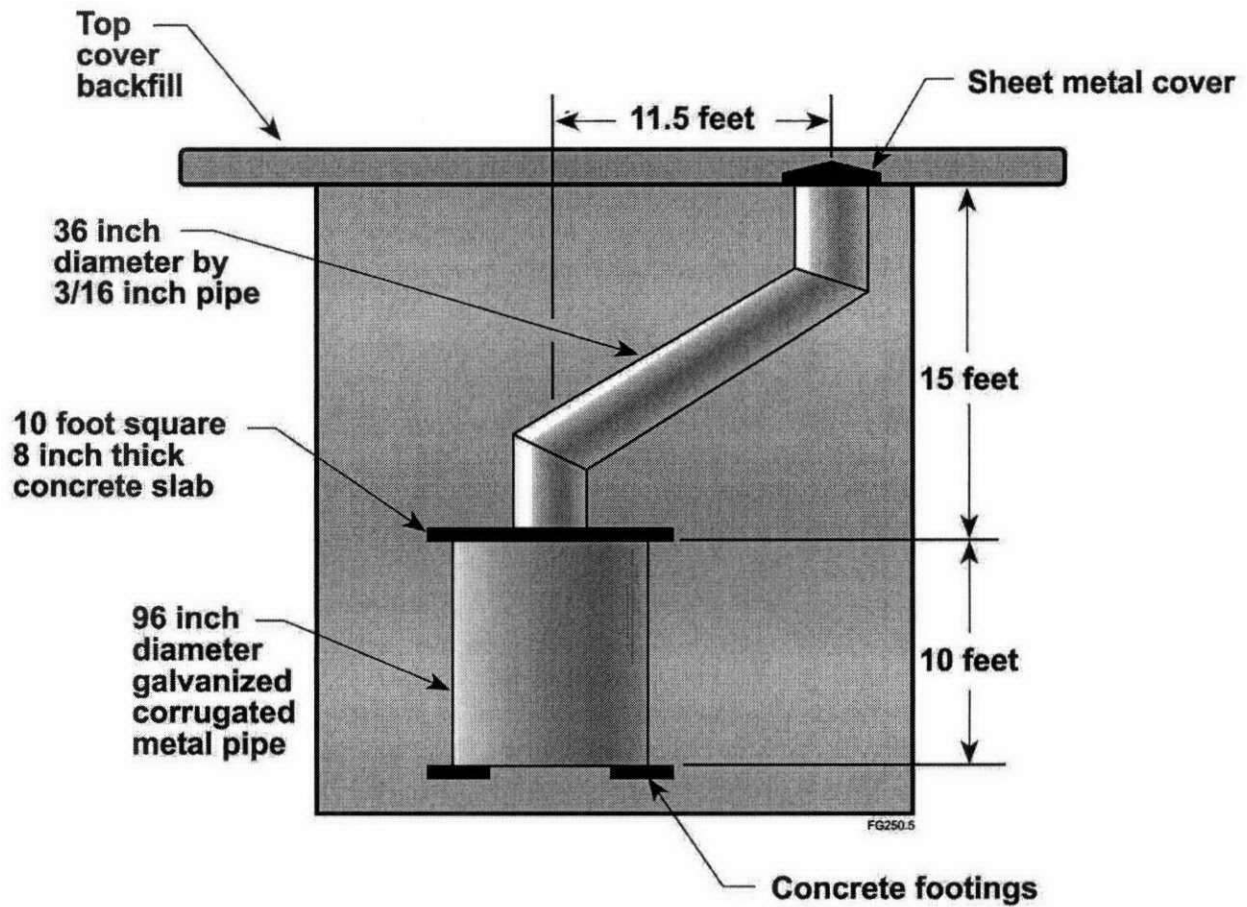
The 618-11 site was opened in March 1962 and accepted waste to Trench 1 until October 3, 1962. The burial ground was then taken out of service pending a U.S. Atomic Energy Commission review and approval of the 618-11 burial ground location. During the closure period, a second trench and 40 VPUs were added. The burial site was brought back online when the 618-10 burial site went through closure at the request of the Atomic Energy Commission. Trench 3 was added after the burial ground was reopened along with an additional 10 VPUs and 3 to 5 caissons. Trench 3 had not been completely filled with waste at closure of the 618-11 site in December 1967.

Figure 2-4. The 618-11 Waste Burial Ground.



FG250.2

Figure 2-5. A 618-11 Site Caisson.



The site contains a broad spectrum of low-level waste including fission products, byproduct material (thorium and uranium), and plutonium. The site was used for the disposal of 300 Area laboratory solid wastes. Low-activity wastes were received from the following facilities: 303, 305, 306, 309, 313, 321, 324, 325, 325-A, 325-B, 326, 327, 329, 333, 340 Complex, 3706, 3707-C, 3718, 3730, and 3732. These facilities all handled radioactive contaminated, or potentially contaminated, waste from operations or laboratory areas, including hot cells. Moderate- and high-activity (remote-handled) waste was received from the 327 radiometallurgy hot cells, 325-A hot cells, the 325-B (analytical) hot cells, occasionally from the Plutonium Recycle Test Reactor 309 Building, and later from 324 hot cells. The low- to moderate-activity dry solid wastes were disposed to trenches (with some exceptions) and the moderate- to high-activity wastes were disposed to VPUs and caissons. The 325-A hot cells disposed of moderate- to high-activity waste to the trenches in concrete lead-shielded drums. The 325-B hot cells also used concrete-shielded drums to dispose of hot cell waste, used laboratory containers and glassware, and spent instruments and equipment. Some plutonium residues were encapsulated in concrete and placed in lead and concrete-shielded drums at the 325 Building by 340 Building operators servicing various organizations and facilities, including the 308 Building.

A tritium plume has been detected outside the fenced area of the 618-11 site. The plume is currently being monitored and samples taken to try and determine the source. Activities associated with this plume are not part of this BIO unless sampling is required inside the fenced boundary of the 618-11 site.

2.3.2 Significant Abnormal Occurrences (Unplanned Releases)

The 618-11 site had seven documented unplanned releases during its operational life.

In September 1963, a milk pail container that was externally contaminated with a significant amount of loose, highly radioactive material was discharged into a vertical waste caisson causing a contamination spread. Although the wind was less than 10 mi/h, an area of contamination was identified that measured approximately 400 ft² (36 m²) around the barrel. The cask truck had smearable contamination on the inside of one tire.

In March 1964, a trailer truck hauling two waste casks from the 327 Building attempted to deposit waste into a VPU. As a waste can was dropped into the VPU, a "blowback" of radioactive material occurred, contaminating four employees, the vehicle, and approximately 1,000 ft² (90 m²) of ground on the site.

In May 1964, a contamination incident occurred while dumping canned waste from the 325 Building from a waste cask. The waste truck was positioned over a VPU and the waste chute was opened. Fine white powder was seen drifting out of the chute. Approximately 1,800 ft² (167 m²) of ground was contaminated along with two employees.

In February 1965, wind blew waste from a truck and contaminated a worker and the ground. Ground contamination covered approximately 1,400 ft² (130 m²).

In March 1965, during the burial of a box containing a highly contaminated filter from the 327 Building, an employee became contaminated. The truck was positioned at the burial trench and the truck bed was tilted. The employee left the truck cab to see why the box would not slide off the truck and noticed clouds of dust emitting from the box seams. The employee was contaminated and the immediate areas received spotty contamination.

In April 1967, during routine burial operations, a contamination spread occurred involving waste from the 327 Building that was being deposited into a VPU through a chute from a cask. The operation was being performed from the upwind side of the cask. At the moment the waste was dropped into the chute, the wind reversed in a strong gust, causing the airborne spread of contamination. Approximately 30 ft² (2.7 m²), three employees, and the transport truck were contaminated.

In April 1967, during routine burial operations, a piece of waste became wedged in a truck chute causing an airborne release of contamination. The waste was being transported in a new 5-ton (4,500-kg) cask. After releasing the waste from the cask to a VPU, the dose rate at the bore of the cask remained at the initial level of 450 millirads/h, indicating that some of the waste did not clear the cask. A water rinse of the cask bore had no effect in reducing the dose rate. A worker taped a plastic cover over the head of the cask and withdrew from the area. Three employees were found to have skin contamination. Two pickup trucks were contaminated. A survey of the ground found contamination in a fan shape with maximum levels of 50 millirads/h. Contamination was found outside the fenced area. The ground around the VPU, inside the fence, was covered with clean gravel. The contaminated area outside the fence was turned over with a bulldozer, into windrows, to bury the contamination and prevent it from blowing away. The area was posted with radiation signs but later released from radiation zone status. The area outside the fence is known as UPR-600-22, WPPSS Windrow Site.

After each release, the ground was either washed down using fire trucks or gravel was spread over the contaminated area to prevent the spread of contamination.

2.4 CHARACTERIZATION AND SURVEILLANCE

Final cleanup activities for the 618-10 and 618-11 sites are scheduled for completion in 2018. Before removal activities are initiated, the waste sites and associated waste will be characterized. The following activities are covered, unless otherwise noted, under this safety basis. Any modification to these activities will require an Unreviewed Safety Question evaluation, as required in 10 CFR 830.203, "Unreviewed Safety Question Process."

2.4.1 Surveillance Activity

Surveillance of site surfaces is conducted annually to determine whether any contamination has either risen to the surface of the burial site or blown in from other areas. This activity is done with a Rad Rover, a 14' wide 28' long 35,000 pound mobile vehicle equipped with radiological survey detectors that is driven over the site. This activity will be continued until work is initiated to remove the buried waste.

Maintenance activities that include maintaining the fence, rodent control or extermination, and control of tumble weeds will continue through the life of the site.

2.4.2 Groundwater Monitoring

Current groundwater monitoring activities performed outside the fence boundary will continue during all phases of the burial ground cleanup. Groundwater monitoring activities are performed outside the 618-10 and 618-11 site fences and are not considered part of the scope of this BIO.

Additional groundwater monitoring may be initiated using boreholes drilled inside the fences or site boundaries. The boreholes used for water monitoring would be inside the fences but not internal to the caissons, VPUs, or trenches. The ground water monitoring equipment will be used for determination if any contamination has migrated from the caissons, VPUs or trenches during characterization activities. These wells will not be installed as a permanent wells.

2.4.3 Characterization

Visual characterization (intrusive) will be done to observe the integrity of the VPUs, the caissons, and the waste containers. This information can be used in the development of options for remediation activities.

Analytical information obtained from samples will be used initially to identify radiological and hazardous conditions that will be encountered during remediation activities (not covered in this BIO) and to help specify the waste streams that will be generated at the 618-10 and 618-11 sites. These technical services also will be used to characterize waste for disposal and to verify area conditions during work activities. Analytical data generated during sampling activities will be used to develop the following information:

- Contamination identification
- Contamination concentrations
- Waste type categories
- Worker health and safety conditions
- Operational precautions
- Waste treatment requirements
- Waste packaging and disposal requirements.

Sample collection in support of these analytical studies will be performed at specific times throughout the cleanup activities to provide current site information and to identify changes to initial information.

Sample collection is separated into two groups: nonintrusive sampling and intrusive sampling.

2.4.3.1 Nonintrusive Sampling Activities

Two types of nonintrusive characterization are used at the 618-10 and 618-11 sites. The first is the radiation survey (the surveillance activity) that is done to determine whether any

contamination has either risen to the surface of the burial site or has blown in from other areas. This activity is done with a Red Rover, a mobile vehicle equipped with radiological survey detectors that is driven over the site. This activity is completed once a year.

The other nonintrusive sampling activity is conducted using ground-penetrating radar. This method uses a transducer to transmit FM frequency, electromagnetic energy into the ground. The reflections back from the interfaces in the ground help map what has been buried. Electromagnetic induction (EMI) is a method of detecting and mapping shallow subsurface features and is compatible with ground-penetrating radar. The EMI technique investigates the electrical conductivity properties of subsurface soil, rock, or groundwater. The EMI equipment records a composite conductivity value that represents the combined effects of the thickness, depth, and specific conductivity of each stratigraphic layer, as well as any nonnatural conductive object such as metallic drums and solid debris.

EMI data points are normally taken along profile lines within a grid system. Computer software converts the points to a contour plot. A grid pattern will be set up prior to collection of information. Information gathered from this type of sampling will help determine the location of the trenches, the VPUs, and in the 618-11 site, the caissons.

2.4.3.2 Intrusive Sampling Activities

Physical samples will be collected in the trenches, outside the VPUs and caissons, and inside the VPUs and caissons. These sampling activities will employ a variety of sampling processes.

- Soil vapor sampling will be performed using the GeoProbe¹ (or equivalent direct push methods) to install gas-sampling points for the collection of soil vapor samples exterior to the VPUs and the caissons.
- A caisson or VPU may be breached using a cone penetrometer or similar drilling system or equipment. Once the caisson or VPU has been entered, a solid sample can be extracted and video camera or a radiation monitor can be inserted.
- A split spoon core drilling system (or equivalent type of system) may be used to remove a measured amount of soil or waste from the burial sites.
- Pits may be excavated to remove a sample. This method requires the use of a backhoe digging down to the top of a caisson, a VPU, or trench. This activity has been evaluated in this BIO.

¹ GeoProbe is a trademark of KEJR Engineering, Inc.

All intrusive sampling activities will be completed as described in the Sample Analysis Plan, which will be approved by DOE and the regulators.

3.0 HAZARDS AND ACCIDENT ANALYSIS

3.1 INTRODUCTION

This section describes the methodology, approach for preparation, and the results of a hazard and accident analysis for the 618-10 and 618-11 sites. The analysis presented in this chapter is intended to satisfy the safety analysis principles in DOE-STD-1027-92, commensurate with the operational complexity and the magnitude of the hazards. The analysis is also intended to meet the guidance or requirements of the following documents:

- DOE-STD-3011-2002, *Guidance for Preparation of Basis for Interim Operation (BIO) Documents*
- HNF-PRO-700, *Safety Basis Development*
- HNF-8739, *Hanford Safety Analysis and Risk Assessment Handbook (SARAH)*
- 10 CFR 830, "Nuclear Safety Management"
 - Section 830.202, "Safety Basis"
 - Section 830.204, "Documented Safety Analysis"
 - Section 830.205, "Technical Safety Requirements"
 - Section 830.207, "DOE Approval of Safety Basis."

3.2 HAZARDS CATEGORIZATION

3.2.1 Initial Hazards Categorization

The initial hazard categorization for the 618-10 site was Hazard Category 3, and the initial hazard categorization for the 618-11 site was Hazard Category 2. The hazard category was determined using the requirements in DOE-STD-1027-92 and HNF-8739, *Hanford Safety Analysis and Risk Assessment Handbook*. This designation was based on the estimated inventory at the sites and documented in Appendix A.

3.2.2 Final Hazards Categorization

The final categorization is based on the material at risk (MAR) from the unmitigated release of the largest quantity of available hazardous material from one of the accidents described in Section 3.6. The radioactive material used as the MAR is located in caissons, VPUs, and trenches throughout the 618-11 site. It is assumed that the entire inventory was distributed evenly between the VPUs and the caissons. There are 50 VPUs and a minimum of 3 caissons located in the 618-11 site. Fifteen percent of the total inventory is assumed to be in each caisson. This number is derived from evenly distributing the inventory across the total possible volume of three caissons and the VPUs. Each caisson holds the same volume as approximately 13.5 VPUs.

Due to the location of each underground unit, the accidents in Section 3.6 only impact one unit. Therefore, according to DOE-STD-1027-92, the standard permits the concept of facility segmentation provided the hazardous material in one segment could not interact with hazardous materials in another segment.

The estimated radionuclide inventory from the 618-10 site is 1,000 Ci of ^{90}Sr , 1,000 Ci of ^{137}Cs , and 12.5 Ci of ^{239}Pu . There are 94 VPUs (no caissons) in the 618-10 site with less than 5 percent of the inventory in each unit. (The total Pu source term is divided amongst the 94 VPUs and rounded up to add conservatism). The hazard category is determined in Table 3-1 based on the estimated inventory.

Table 3-1. Estimated Radionuclide Inventory for the 618-10 Site.

Radionuclide	Inventory per Unit (Ci)	DOE-STD-1027-92 Attachment 1, Table A.1			
		Category 2 Threshold Quantity (Ci)	Ratio of Inventory to Category 2 Threshold Quantities	Category 3 Threshold Quantities (Ci)	Ratio of Inventory to Category 3 Threshold Quantities
Sr-90	50	2.2 E+04	2.3 E-03	1.6 E+01	3.1
Cs-137	50	8.9 E+04	5.6 E-04	6.0 E+01	8.3 E-01
Pu-239	0.63	5.6 E+01	1.1 E-02	5.2 E-01	1.2
		Sum of Ratios	1.4 E-02	Sum of Ratios	5.2

The final hazard categorization for site 618-10 is Hazard Category 3.

The 618-11 inventory of 1,000 Ci of ^{90}Sr , 1,000 Ci of ^{137}Cs , and 622 Ci of ^{239}Pu was used for the accidents analyzed in Section 3.6. The 618-11 site has 50 VPUs and 3 to 5 caissons. Volume distribution calculations assumed 3 caissons. The MAR from the accident is 15 percent of the total activity of the 618-11 waste site or 150 Ci of ^{90}Sr , 150 Ci of ^{137}Cs , and 93.3 Ci of ^{239}Pu .

The accident analysis that had the largest onsite and offsite release is presented in Section 3.6.2, "Caisson Penetration with Fire." As stated in DOE-STD-1027-92 under Section 3.1.2, "Final Hazards Categorization," if credible release fractions can be shown to be significantly different than those values based on physical and chemical form and available dispersive energy sources, the threshold inventory values for Category 2 Table A.1 may be divided by the ratio of maximum potential release fraction to that found on Page A-9 of DOE-STD-1027 (Solid/Powder/Liquid = 1×10^{-3}). The airborne release fraction (ARF) calculated from Section 3.6.2.2 is 3.2×10^{-4} . The ratio would provide a new Category 2 threshold quantity value.

Example

$$\frac{2.2 \times 10^4 \text{ Ci } ^{90}\text{Sr}}{\frac{3.2 \times 10^{-4}}{1 \times 10^{-3}}} = 6.9 \times 10^4 \text{ Ci}.$$

The hazard category is determined in Table 3-2 based on the recalculated threshold quantities.

Table 3-2. Estimated Radionuclide Inventory for the 618-11 Site.

Radionuclide	Inventory per Unit (Ci)	DOE-STD-1027-92 Attachment 1, Table A.1			
		Category 2 Threshold Quantities (Ci)	Ratio of Inventory to Category 2 Threshold Quantities	Recalculated Category 2 Threshold Quantities (Ci)	Ratio of Inventory to Category 2 Threshold Quantities
Sr-90	150	2.2 E+04	6.8 E-03	6.9 E+04	2.2 E-03
Cs-137	150	8.9 E+04	1.7 E-03	2.8 E+05	5.4 E-04
Pu-239	93.3	5.6 E+01	1.7	1.8 E+02	5.3 E-01
		Sum of Ratios	1.7	Sum of Ratios	5.4 E-01

The total sum of the ratios for the 618-11 site after recalculating the threshold limits is less than 1. The final hazard categorization for the 618-11 site is Hazard Category 3.

3.3 HAZARD IDENTIFICATION

The objective of the hazard identification process is to provide a basis for the analysis of the hazards associated with surveillance, characterization, and groundwater monitoring activities at the 618-10 and 618-11 sites. To meet this objective, the hazard identification process addressed the following:

- Identify potential energy sources capable of interacting with the radioactive and hazardous materials
- Identify possible scenarios from potential energy sources near hazardous and radioactive materials that may lead to a significant release
- Screen potential scenarios and select bounding accidents for further analysis
- Determine inventory (material, quantity, form and location) for each site based on the best available information.

The preliminary hazards analysis produced a “What-If” table of hazards, consequences, potential engineered administrative features to mitigate or control hazards, and comments. The information in the “What-If” table is provided in Appendix C.

3.4 HAZARDS IDENTIFICATION RESULTS

The process used to identify Hazards associated with characterization of the 618-10 and 618-11 Burial sites is described in HNF-8739 Hanford Safety Analysis and Risk Assessment Handbook. A preliminary hazards analysis checklist (table C-1) was completed with support from the project which provided information for table 3-3, Hazard Energy Source Form.

A list of hazards for the 618-10 and 618-11 sites was developed at a preliminary hazards analysis on December 19, 2002, that was attended by representatives from the Central Plateau Remediation Project (CP) Groundwater Protection Program, CP Radiation Control, CP Engineering, CP Nuclear Safety, CP Fire Protection, and DOE, Richland Operations Office. The list of hazards was generated using the Hazards Identification Checklist and Energy Designator from HNF-8739. The checklist provides a list of hazard categories (e.g., electrical, flammable materials, and ionizing radiation sources) to assist in the identification process (see Appendix C). The existence of any additional hazards not appearing on the checklist was noted. The potential hazards associated with surveillance, characterization, and groundwater monitoring activities were identified by reviewing historical documentation and holding discussions with subject matter experts. Due to the lack of detailed waste descriptions and quantities, the composition of the waste at each site is an estimate. This BIO evaluates both hazardous and radiological waste that could have been buried at the 618-10 and 618-11 sites.

The energy sources that could lead to an accident were identified during the preliminary hazards analysis and are shown in Table 3-3. Common industrial hazards (e.g., electric shock, falling, and noise) were considered only to the extent that they initiated or contributed to accidents for which institutional safety programs (e.g., industrial safety, industrial hygiene) do not provide adequate coverage.

The checklist (Appendix C) identifies the energy sources that apply to the sampling operation. Table 3-3 provides the hazardous energy source form including source and potential consequences. The last column of Table 3-3 provides the disposition of the hazard. Many of the hazards can be treated as standard industrial hazards. These hazards include vehicle accidents, pesticides, animals, and handling drilling equipment. The energy sources may provide a hazard to the workers but are common industrial hazards, which are mitigated by the SMP programs. No additional controls are required for these programs.

Energy sources that might cause onsite or offsite radiological or toxic releases were included in the hazard evaluation.

Table 3-3. Hazard Energy Source Form. (9 sheets)

Hazard/Energy Source	Description	Potential Consequences	Disposition
High voltage distribution system	High voltage lines are overhead	Standard industrial hazard <ul style="list-style-type: none"> – Shock – Electrocution – Could cause loss of power or initiate a fire 	Treated as industrial hazard
480/240/120 V distribution system	Wires supply power to equipment	Standard industrial hazard <ul style="list-style-type: none"> – Shock – Electrocution – Could cause loss of power or initiate a fire 	Treated as industrial hazard
Temporary power	Temporary power may be brought into area (temporary power includes sources such as diesel generators, battery banks)	Standard industrial hazard <ul style="list-style-type: none"> – Shock – Electrocution – Could cause loss of power or initiate a fire 	Treated as industrial hazard
Loss of equipment function	Motors, pumps, fans, heaters, illuminators, instrumentation, system pressure	Standard industrial hazard <ul style="list-style-type: none"> – Pinch – Crush 	Treated as industrial hazard
Combustible liquids	Various quantities and types including diesel fuel oil, lubricating oils, gearbox oils, and hydraulic fluids	Standard industrial hazard and radiological hazard <ul style="list-style-type: none"> – Burns – Chemical exposure – Radiological uptake – Could provide fuel for a fire, which injures workers or releases hazardous material 	Included in the hazard assessment

Table 3-3. Hazard Energy Source Form. (9 sheets)

Hazard/Energy Source	Description	Potential Consequences	Disposition
Flammable liquids	<p>Various quantities and types of solvents used for cleaning or decontamination may be in waste</p> <p>Fuel (e.g., for generator, light plants, portable heaters)</p> <p>Oils and combustible chemicals</p>	<p>Standard industrial hazard and radiological hazard</p> <ul style="list-style-type: none"> – Burns – Chemical exposure – Radiological uptake – Could provide fuel for a fire, which injures workers or releases hazardous material 	Included in the hazard assessment
Flammable/explosive gases (equipment used above surface)	<p>Acetylene used in conjunction with oxygen for welding and cutting (these activities would be performed above surface and not come in contact with the waste buried at either site)</p> <p>Propane-powered heating devices.</p>	<p>Standard industrial hazard and radiological hazard</p> <ul style="list-style-type: none"> – Burns – Chemical exposure – Could provide fuel for a fire, which injures workers or releases hazardous material – Not accessible to the waste in anticipated activities – explosion 	Included in the hazard assessment
Hydrogen generation	Certain waste containers, solution bottles, batteries, etc.	<p>Radiological hazard</p> <ul style="list-style-type: none"> – Radiological uptake – Buildup could cause overpressurization or ignite to cause an explosion that injures workers or releases hazardous material 	Included in the hazard assessment

Table 3-3. Hazard Energy Source Form. (9 sheets)

Hazard/Energy Source	Description	Potential Consequences	Disposition
Spontaneous combustion	Pyrophoric material may be present in some storage areas, holdup in equipment Petroleum-based products, reactive chemicals, nitric acid and organics	Radiological hazard – Radiological uptake – Could result in fire that releases hazardous material – burns	Included in the hazard assessment
Combustible solids	Wood, plastic, tape, clothing, rags, paint, rubber, may be in the waste	Radiological hazard – Radiological uptake – Could result in fire that releases hazardous material	Included in the hazard assessment
Portable lighting	Localized lighting may be used	Standard industrial hazard – Burns – Could cause fires or melt plastic confinement barriers causing a spill – Loss of visibility	Included in the hazard assessment
Open flames	Oxyacetylene, arc, welding, soldering may be used	Standard industrial hazard and radiological hazard – Burns – Contamination – Toxic fume inhalation – Could provide ignition source and fuel for a fire	Included in the hazard assessment
High-temperature devices	Engine exhaust surfaces, lights	Standard industrial hazard – Burns – Toxic fumes – fire	Treated as industrial hazard
Grinding and cutting tools	Various hand tools to be used	Standard industrial hazard – Lacerations – Punctures – Repetitive motion – Could injure workers or result in a fire	Treated as industrial hazard

Table 3-3. Hazard Energy Source Form. (9 sheets)

Hazard/Energy Source	Description	Potential Consequences	Disposition
Temporary heaters	Used for personal comfort and freeze protection	Standard industrial hazard <ul style="list-style-type: none"> – Burns – Could injure workers or result in a fire 	Treated as industrial hazard
High-temperature environment	High-temperature work environment due to hot weather Work may require personal protective equipment	Standard industrial hazard <ul style="list-style-type: none"> – Heat stress 	Treated as industrial hazard
Low-temperature environment	Low-temperature work environments due to cold weather	Standard industrial hazard <ul style="list-style-type: none"> – Cold stress 	Treated as industrial hazard
Calibration and radiological monitoring sources	Calibration sources used in radiological monitoring equipment	Radiological hazard <ul style="list-style-type: none"> – Radiation exposure 	Treated as industrial hazard
Fissile material storage/holdup	Fissile isotopes in waste	Radiological hazard <ul style="list-style-type: none"> – Radiation exposure – Radiological uptake – Contamination – Could be released due to drops or impacts, fires, overpressurization or explosions, or external events – Could cause criticality 	Included in the hazard assessment
Contaminated water	Low-level contaminated water may be generated	Radiological hazard <ul style="list-style-type: none"> – Radiation exposure – Radiological uptake – Contamination – Could be released due to spills, explosions 	Included in the hazard assessment
General contamination	Loose surface contamination and fixed contamination may be disturbed by sampling	Radiological hazard <ul style="list-style-type: none"> – Radiation exposure – Radiological uptake – Contamination – Could be released due to spills, explosions 	Included in the hazard assessment

Table 3-3. Hazard Energy Source Form. (9 sheets)

Hazard/Energy Source	Description	Potential Consequences	Disposition
Actinide solution	Residual solutions in waste in containers and bottles	Radiological hazard <ul style="list-style-type: none"> – Radiation exposure – Radiological uptake – Contamination – Could be released due to spills, explosions – criticality 	Included in the hazard assessment
Contaminated oil and antifreeze	Contamination in oil buried at waste site	Radiological hazard <ul style="list-style-type: none"> – Radiation exposure – Radiological uptake – Contamination – Could be released due to spills, explosions – Environmental hazard 	Included in the hazard assessment
Waste containers	Various isotopes found in waste	Radiological hazard <ul style="list-style-type: none"> – Radiation exposure – Radiological uptake – Contamination – Could be released due to spills, explosions – criticality 	Included in the hazard assessment
Ionizing radiation devices	Radiological equipment used for X-ray	Radiological hazard <ul style="list-style-type: none"> – Radiation exposure 	Treated as industrial hazard
Nonionizing radiation sources	Computers, welding and cutting devices, ground-penetrating radar used to characterize site, laser for welding	Industrial Hazard <ul style="list-style-type: none"> – Radiation exposure 	Treated as industrial hazard
Drilling/digging operations (above ground activities)	Trucks, motors, drills	Standard industrial hazard <ul style="list-style-type: none"> – Loss of hearing – Does not initiate or impact hazardous material releases 	Treated as industrial hazard
Air compressors	Stationary and portable air compressors	Standard industrial hazard <ul style="list-style-type: none"> – Does not initiate or impact hazardous material releases 	Treated as industrial hazard

Table 3-3. Hazard Energy Source Form. (9 sheets)

Hazard/Energy Source	Description	Potential Consequences	Disposition
Rotating equipment	Compressors, electric motors	Standard industrial hazard <ul style="list-style-type: none"> – Pinch – Impact – Puncture – Cut – Could result in loss of confinement 	Treated as industrial hazard
Vehicle/transport devices	Forklifts, loaders, trucks	Standard industrial hazard <ul style="list-style-type: none"> – Impact – Radiological uptake, exposure – Could injure workers or result a release due to spill or puncture that releases hazardous material. – Could provide fuel for a fire or cause an explosion, which injures workers or releases hazardous material 	Included in the hazard assessment
Pressurized gas bottles - above ground	Welding	Standard industrial hazard <ul style="list-style-type: none"> – Extreme temperatures – Could act as a missile 	Treated as industrial hazard
Pressurized gas bottles - located in the burial sites	Containers that have pressurized due to gas generation	Radiological hazard <ul style="list-style-type: none"> – Punctured during sampling activities causing a pressurization leading to a release 	Included in the hazard assessment
Compressed air	Compressed air used to operate equipment	Standard industrial hazard <ul style="list-style-type: none"> – Pressure release 	Treated as industrial hazard
Crush, shear, pinch	Puncture, sharp edges, motors, fans, pumps	Waste containers breached	Included in the hazard assessment

Table 3-3. Hazard Energy Source Form. (9 sheets)

Hazard/Energy Source	Description	Potential Consequences	Disposition
Hoisting and rigging, lifting equipment	Heavy equipment may be lifted and lowered as part of sampling	Standard industrial hazard and radiological hazard <ul style="list-style-type: none"> – Impact and crushing – Load drop – Radiological uptake – Could result in spill that releases hazardous material 	Included in the hazard assessment
Chemicals	Paints, acids, reagents, oxidizers	Chemical/standard industrial hazard <ul style="list-style-type: none"> – Chemical exposure – Burns – Asphyxiation – Could be released due to spills, fires, overpressurization due to chemical reactions 	Included in the hazard assessment
Shock-sensitive chemicals	Nitrates or other shock-sensitive chemicals may be located in waste	Chemical/standard industrial hazard/radiological hazard <ul style="list-style-type: none"> – Chemical exposure – Burns – Asphyxiation – Could cause explosion 	Included in the hazard assessment
Explosive substances	H ₂ gas generated in waste Various quantities and types of solvents used for cleaning or decontamination may be in waste	Chemical/standard industrial hazard/radiological hazard <ul style="list-style-type: none"> – Chemical exposure – Burns – Asphyxiation – Could cause explosion 	Included in the hazard assessment

Table 3-3. Hazard Energy Source Form. (9 sheets)

Hazard/Energy Source	Description	Potential Consequences	Disposition
Asbestos	Asbestos-containing material (e.g., ceiling tiles, walls, pipe insulation, floor tiles) in waste	Chemical/standard industrial hazard – Asbestos dust inhalation – Could be released due to spills, fires, etc. (no offsite impact)	Treated as industrial hazard
Lead	Lead-containing material in waste	Chemical/standard industrial hazard – Lead poisoning – Fume inhalation – Could be released due to fire (no offsite impact)	Treated as industrial hazard
Polychlorinated biphenyls	Polychlorinated biphenyls in various parts of the facility (e.g. light ballasts, transformers)	Chemical/standard industrial hazard – Contamination – Could be released due to spills, fires, etc. (no offsite impact)	Treated as industrial hazard
Sodium	May be present in waste	Fire potential/radiological hazard Corrosion	Included in the hazards assessment
Pesticides sprayed around area	Noxious weed control relies on aerial application of pesticides	Chemical/standard industrial hazard – Chemical exposure	Treated as industrial hazard
Animal droppings	May encounter animal and bird droppings	Standard industrial hazard – Disease	Treated as industrial hazard
Animals	May encounter dead animals Live animals such as snakes may be in waste site	Standard industrial hazard – Disease – Bites	Treated as industrial hazard

Table 3-3. Hazard Energy Source Form. (9 sheets)

Hazard/Energy Source	Description	Potential Consequences	Disposition
Lightning	May experience natural phenomena	Radiological/chemical/ standard industrial hazard <ul style="list-style-type: none"> – Burns – Shock – Could injure workers or release hazardous material through spills, loss of confinement or resultant fires 	Included in the hazards assessment
High winds, tornadoes, heavy rain, floods, heavy snow, earthquakes, aircraft crash	May experience natural phenomena	Radiological/chemical/ standard industrial hazard <ul style="list-style-type: none"> – Bodily injury – Dust from inhalation – Radiological uptake – Could injure workers or release hazardous material through spills or resultant fires 	Included in the hazards assessment
Digging operations into waste vessel or trench	Sampling will require digging and drilling	Standard industrial hazard/radiological hazard <ul style="list-style-type: none"> – Burial – Shock – Cave-in – Fall – Pressure release 	Included in the hazards assessment

3.5 HAZARD EVALUATION

Energy sources that could lead to an accident are identified in Table 3-3. The preliminary hazards analysis used a "What-If" format to evaluate the potential accidents. The hazard evaluation has been reformatted to consider events rather than the "What-If" checklist in appendix C and is provided in Table 3-4. Table 3-4 presents the hazards summary, preventative and mitigative features, and the event rankings for the 618-10 and 618-11 sites. This table also provides information on additional analysis performed for hazards that are considered to be credible and a potential risk to offsite personnel, onsite worker or the environment.

The significance of the scenarios identified in the hazard analysis is based on the consequences and frequencies of those scenarios. Each postulated accident scenario frequency is classified as anticipated, unlikely, extremely unlikely, and beyond extremely unlikely, and the consequences are classified as high, moderate, or low. Scenarios are classified into risk bins depending on their consequences and frequency. Criteria for classifying frequency are given in Table 3-5 and for classifying consequences in Table 3-6. Table 3-7 provides the risk bins showing the severity of the hazards. Classifying the scenarios based on assigned estimates of consequence allows the accident scenarios to be ranked for further analysis.

The classification is a temporary one to enable binning of the accident scenarios. Once the representative accident of each binned grouping has been analyzed, the resulting consequences to the onsite worker and offsite public, when compared with the radiological criteria, determine the need for controls. The dominant scenarios are evaluated further to determine the potential for administrative controls, compensatory or corrective measures, and restrictions on facility operations to reduce the risk. Selected lower risk scenarios also are analyzed to ensure complete coverage of controls and to reflect activities that will be repeated in the facility during cleanup. TSR controls will be required for events that result in offsite doses exceeding 25 rem. TSR controls will be considered for events that produce doses offsite between 1 rem and 25 rem. Additional controls may be imposed to Risk Bins III or IV for the collocated worker. TSR controls are therefore required for high-consequence events and may be applied to moderate-consequence events. Risk reduction features are specified as "defense-in-depth" for events in Risk Bins I or II, as required, to move the consequences to a lower risk bin.

Table 3-4. Hazards Evaluation for the 618-10 and 618-11 Sites. (6 sheets)

	Hazard Summary				Preventive and Mitigative Features		Event Rankings				Comments (Analysis)
	Potential Event	Area	Hazard Type	Event and Possible Causes	Engineered	Administration	Freq Cat	Consequence Categories			
								Facility Worker	Onsite Worker	Offsite Public	
1	Drilling breaches caisson	618	Radioactive material; hazardous material; kinetic energy	Drilling causes inadvertent breach of caisson, which results in radioactivity being released to environment	Soil overburden	Geophysical surveys guide operation Sample analysis Plan Emergency Management Program	A	L Risk Bin III	L Risk Bin III	L Risk Bin III	Possible radiological impact to worker (Section 3.6.1)
2	Vehicle fire heating waste	618	Radioactive material; hazardous material; kinetic energy	Spill of vehicle fuel in conjunction with drilling ignites as caisson is penetrated igniting waste, which results in radioactivity being released to the environment	Soil overburden	Emergency Management Program	U	L Risk Bin III	L Risk Bin III	L Risk Bin III	Possible radiological impact to worker (Section 3.6.2)
3	Drilling causes fire (flammable gases or waste)	618	Radioactive material; hazardous material; criticality	Drill penetrates caisson causing ignition of flammable gas or waste in caisson	Soil overburden	Emergency Management Program Sample analysis Plan Geophysical surveys guide operation	U	L Risk Bin III	L Risk Bin III	L Risk Bin III	Possible radiological impact to worker (Section 3.6.2)

Table 3-4. Hazards Evaluation for the 618-10 and 618-11 Sites. (6 sheets)

	Hazard Summary				Preventive and Mitigative Features		Event Rankings				Comments (Analysis)
	Potential Event	Area	Hazard Type	Event and Possible Causes	Engineered	Administration	Freq Cat	Consequence Categories			
								Facility Worker	Onsite Worker	Offsite Public	
4	Sampling disturbs contaminated soil (inadvertent excavation into the site)	618	Radioactive material; hazardous material	Sampling operation disturbs contaminated soil causing unplanned release		Emergency Management Program Radiation protection Geophysical surveys guide operation Sample Analysis Plan	A	L Risk Bin III	L Risk Bin III	L Risk Bin III	Possible radiological impact to worker; no criticality review for water sampling required (Section 3.6.3)
5	Criticality	618	Radiation exposure	Reconfiguration of material or introduction of water causes a criticality		Criticality program	BEU	L Risk Bin IV	L Risk Bin IV	L Risk Bin IV	(Section 6.0)
6	Aircraft impact	618	Radioactive material, hazardous material	Aircraft strikes waste site operations	Soil overburden	None	EU	L Risk Bin IV	L Risk Bin IV	L Risk Bin IV	No additional evaluation required (Section 3.5.1)

Table 3-4. Hazards Evaluation for the 618-10 and 618-11 Sites. (6 sheets)

	Hazard Summary				Preventive and Mitigative Features		Event Rankings				Comments (Analysis)
	Potential Event	Area	Hazard Type	Event and Possible Causes	Engineered	Administration	Freq Cat	Consequence Categories			
								Facility Worker	Onsite Worker	Offsite Public	
7	Vehicle impact sampling truck	618	Radioactive material, kinetic energy	Ground vehicle impacts sampling truck resulting in potential release of radioactive materials (possible causes include mechanical failure and operator error)	Fenced site	Restricted access	U	L Risk Bin III	L Risk Bin III	L Risk Bin III	A vehicle impact followed by a fire is judged to be an unlikely event (enveloped by analysis in Section 3.6.2)
8	Brush fire	618	Radioactive material; hazardous material	Brush fire enters 618 area	Soil overburden	Fire department	A	L Risk Bin III	L Risk Bin III	L Risk Bin III	Fires do not penetrate the soil (no further analysis required)

Table 3-4. Hazards Evaluation for the 618-10 and 618-11 Sites. (6 sheets)

	Hazard Summary				Preventive and Mitigative Features		Event Rankings				Comments (Analysis)
	Potential Event	Area	Hazard Type	Event and Possible Causes	Engineered	Administration	Freq Cat	Consequence Categories			
								Facility Worker	Onsite Worker	Offsite Public	
9	Activities at adjacent facilities or adjacent sites	618	Radioactive material; hazardous material	Activities associated with the groundwater monitoring of the plume next to 618-11 and sampling activities at the unplanned release site next to 618-10	Soil overburden	None	U	L Risk Bin III	L Risk Bin III	L Risk Bin III	The site is not manned on a continuous basis, only when work activities are being performed; an accident at Energy Northwest, an adjacent well for monitoring, or during sampling activities outside the fence could cause evacuations of the site; the waste would not be impacted (no further evaluation required)

Table 3-4. Hazards Evaluation for the 618-10 and 618-11 Sites. (6 sheets)

	Hazard Summary				Preventive and Mitigative Features		Event Rankings				Comments (Analysis)
	Potential Event	Area	Hazard Type	Event and Possible Causes	Engineered	Administration	Freq Cat	Consequence Categories			
								Facility Worker	Onsite Worker	Offsite Public	
10	Subsidence	618	Radioactive material; hazardous material	Truck driving over trench, vertical pipe unit, or caisson causing the earth to subside and releasing radioactive material	Soil overburden	Geophysical surveys guide operation	A	M Risk Bin I	L Risk Bin III	L Risk Bin III	Ground collapse and possible truck turnover causing crushing hazard to worker; radiological hazard is bounded by a release and fire in digging a pit accident (Section 3.6.4)
11	Natural phenomena	618	Radioactive material; hazardous material	Natural phenomena, such as earthquake, high winds, occur during sampling	Soil overburden	None	A	L Risk Bin III	L Risk Bin III	L Risk Bin III	Consequence bounded by explosion/fire in caisson (Section 3.6.2)
12	Backhoe falls into sampling pit	618	Radioactive material; hazardous material	Backhoe or truck falls into pit and fuel from vehicle ignites		Job Hazards Analysis	A	M Risk Bin I	L Risk Bin III	L Risk Bin III	Crushing hazard to worker; possible radiological impact to worker (Section 3.6.4)
13	Sample container or storage drum impact	618	Radioactive material; hazardous material	Vehicle backs into drums containing contaminated soil or samples		Job Hazards Analysis	A	L Risk Bin III	L Risk Bin III	L Risk Bin III	Soil retrieved from boring activities may be contaminated (Section 3.6.3)

Table 3-4. Hazards Evaluation for the 618-10 and 618-11 Sites. (6 sheets)

	Hazard Summary				Preventive and Mitigative Features		Event Rankings			Comments (Analysis)	
	Potential Event	Area	Hazard Type	Event and Possible Causes	Engineered	Administration	Freq Cat	Consequence Categories			
								Facility Worker	Onsite Worker		Offsite Public

A = anticipated.

BEU = beyond extremely unlikely.

EU = extremely unlikely.

L = low.

M = moderate.

U = unlikely.

Table 3-5. General Criteria for Frequency Assessment.

Estimated Annual Frequency	Frequency Notation	Description
Anticipated: $10^{-2}/\text{year} \leq f < 10^{-1}/\text{year}$	A	Has occurred or is likely to occur during the lifetime of the facility
Unlikely: $10^{-4}/\text{year} \leq f < 10^{-2}/\text{year}$	U	Foreseeable, but unlikely to occur during the lifetime of the facility
Extremely Unlikely: $10^{-6}/\text{year} \leq f < 10^{-4}/\text{year}$	EU	Perhaps possible, but extremely unlikely to occur during the lifetime of the facility
Beyond Extremely Unlikely: $f < 10^{-6}/\text{year}$	BEU	Considered too improbable to warrant further consideration

f = frequency.

Table 3-6. General Criteria for Consequence Assessment.

Estimated Consequence	Maximum Offsite Individual	Worker
High	>25 rem TEDE or > ERPG-2/TEEL-2	100 rem TEDE or > ERPG-3/TEEL-3 at the facility boundary ^a or prompt death or serious injury to facility worker
Moderate	≥ 1 rem TEDE or > ERPG-1/TEEL-1	≥ 25 rem TEDE or > ERPG-2/TEEL-2 at the facility boundary ^a or significant radiological or chemical exposure to facility workers ^b
Low	< Moderate consequences	< Moderate consequences

^aNot less than 100 m. For elevated releases, use the point of highest dose.^b“Significant exposure” is one that is qualitatively judged to result in immediate, but reversible, health effects.

ERPG = emergency response planning guideline.

TEDE = total effective dose equivalent.

TEEL = temporary emergency exposure limit.

Table 3-7. Hazard Severity Matrix.

Consequence	Beyond Extremely Unlikely^a (Below 10^{-6})	Extremely Unlikely ($10^{-6} \leq f < 10^{-4}$)	Unlikely ($10^{-4} \leq f < 10^{-2}$)	Anticipated ($10^{-2} \leq f < 10^{-1}$)
High	III	II	I	I
Moderate	IV	III	II	I
Low	IV	IV	III	III

^aExternal events determined to be “Beyond Extremely Unlikely” are not considered further for control set development. “Beyond Design Basis Accidents” for natural phenomena events are evaluated in accordance with DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facilities*.

3.5.1 Binning of Accidents

The accidents in Table 3-4 can be binned under the following representative accidents:

- Penetration of caisson: Item 1
- Fire or explosion induced by sampling activities: Items 2, 3, 7, 11
- Sampling disturbs contaminated soil: Items 4, 13
- Sample pit accident: 10,12
- No further evaluation required: Items 5, 6, 8, 9.

Four types of bounding accidents are identified for further evaluation: penetration of caissons, fire or explosion affecting caisson, disturbance of contaminated soil, and sample pit accident. Items 2, 3, 7, and 11 from Table 3-4 can be grouped together because they all include fires or explosions that affect the waste. Items 4 and 13 deal with possible contaminated soil brought to the surface of a bore hole. Items 10 and 12 are grouped because they both deal with waste from the trench being released to the environment. Any radiological release from subsidence would be bounded by the sampling pit accident.

Item 5, criticality, is categorized as beyond extremely unlikely. Criticality is discussed in Chapter 6. Item 6 is categorized as extremely unlikely and involves an aircraft accident. The aircraft accident does not require further evaluation since the probability of an airplane crash during sampling is extremely unlikely due to the short duration of sampling activities. An airplane crash that happens when no activity is going on at the burial site would not impact the waste in a caisson or VPU because of the depth these units are below the surface. Both burial sites have approximately 4 ft of overburden. As developed in *Hazard Categorization of EM Inactive Waste Sites as Less Than Hazard Category 3* (Roberson 2002), a plane crash would only disturb the top 3 ft of soil. Item 8 is a brush fire that is anticipated but does not impact the waste because the waste is buried. Item 9 involves activities at adjacent facilities that might cause a cessation of operation but would not affect the waste because the waste is protected by the soil.

Hazards to the facility worker have been evaluated. For facility worker hazards identified as risk bin I or II, the hazard has been either; propagated to the accident analysis with risk bin I and II accidents for the onsite worker or offsite public as an industrial hazard only and standard industrial programs credited, or the risk bin I or II radiological risk event has been addressed directly in the table and a TSR AC is credited. Out of the 13 potential events evaluated only two had Risk bin I consequences and have been analyzed in section 3.6.4.

3.5.2 Atmospheric Dispersion

The atmospheric dispersion calculations are performed using the GXQ code, which is the primary software utility used to estimate dispersion coefficients on the Hanford Site. Documentation for the software is found in WHC-SD-GN-SWD-30002, *GXQ 4.0 Program Users' Guide*, and WHC-SD-GN-SWD-30003, 1995, *GXQ 4.0 Program Verification and Validation*. Given the locations of the 618-10 and 618-11 sites, X/Q values presented in HNF-8739 and the software program RADIDOSE were determined to be inappropriate. The 618-10 and 618-11 sites are approximately the same distance from the offsite public and are located between the 300 Area and the 400 Area. The largest inventory is located in the 618-11 site. This site was chosen to calculate the X/Q used in the accident analysis.

The GXQ code uses the joint frequency data to calculate a X/Q' that is exceeded some specified percentage of the time according to the methods specified in Regulatory Guide 1.145, *Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants*. Appendix A of DOE-STD-3009-94 recommends use of the 95th percentile X/Q's. These bounding X/Q's represent minimum dispersion conditions that result in maximum downwind concentrations (i.e., exceeded only a small fraction of the time).

The X/Q's are evaluated for an individual receptor at 100 m in all sectors around the release point and around an irregular boundary where a distance to the Site boundary is given for each sector. In the case of the Site boundary, the distance in each sector is defined to be the minimum distance in a 45° sector centered on the 22.5° direction sector in question (Regulatory Guide 1.145). For the 618-11 site, the distances as read from a Hanford Site map are given in Table 3-8.

The X/Q values calculated using the QXC program are as follows:

$$\begin{aligned}\text{Onsite receptor (100 m)} &= 3.11 \times 10^{-2} \text{ s/m}^3 \\ \text{Offsite receptor} &= 2.28 \times 10^{-5} \text{ s/m}^3.\end{aligned}$$

The Energy Northwest facility is located adjacent to the 618-11 site. The X/Q for the onsite receptor can be used for doses to the Energy Northwest facility.

Lofting effects from the fire scenario are neglected and the conservative ground release has been used.

The GXQ computer input and output are shown in Appendix D.

Table 3-8. Distances from the 618-11 Site to the Hanford Site Boundary.

Sector	Minimum Distance Within a 45° Sector (m)
S	12,250
SSW	11,860
SW	11,860
WSW	16,270
W	22,260
WNW	35,040
NW	37,270
NNW	21,630
N	10,260
NNE	7,430
NE	6,240
ENE	5,890
E	5,990
ESE	5,580
SE	6,290
SSE	7,860

3.6 ACCIDENT ANALYSIS

3.6.1 Sampling Operation Accidentally Penetrates Waste in Caisson or Vertical Pipe Unit

3.6.1.1 Scenario

The 618-10 and 618-11 waste sampling operation includes plans to drill a hole in the ground near or into the top of a caisson or VPU to allow the insertion of instrumentation. This scenario assumes that the sampling operation causes the instrumentation to become contaminated. The material released is assumed reach the surface and cause an airborne release.

3.6.1.2 Source term

The source term for a release from the caisson is calculated as follows:

$$ST = (MAR) (DR) (ARF) (RF)$$

where

ST = source term
 MAR = material at risk
 DR = damage ratio
 ARF = airborne release fraction
 RF = respirable fraction.

The MAR is assumed to be the total inventory of the waste site. Since the 618-11 site has the larger inventory, the accident is assumed to occur in this area. The total activity of the 618-11 site is 1,000 Ci of ^{90}Sr , 1,000 Ci of ^{137}Cs , and 622 Ci of ^{239}Pu . The radioactive material is located in caissons, VPUs, and trenches throughout the waste site. Comparing volumes of vertical pipes and caissons, it is reasonable to assume 15 percent of the radioactive material is located in the caisson affected by this accident (see Section 3.2.2). Because a caisson would hold the largest quantity of waste, the source term associated with the waste volume in a caisson is used for the accident. Only a small fraction of the waste in a caisson will contaminate the sampling instrumentation. One percent of the radioactive material in the caisson is assumed to be affected by the impact on the caisson by the instrumentation. The damage ratio is therefore $0.01 \times 0.15 = 0.0015$. The fraction of material released from the caisson that contaminates the sampling instrument is calculated based on the ARF for an impact of package waste. The ARF is 1×10^{-3} and the respirable fraction (RF) is 0.1 (Table 5-4 of HNF-8739). All the waste released from the caisson is assumed to be released to the atmosphere when the instrument is brought to the surface. The release is therefore

$$\begin{aligned} ST &= (MAR)(DR)(ARF)(RF) \\ &= MAR(0.001)(0.0015)(0.1) \\ &= MAR (1.5 \times 10^{-7}) \\ &= 1.5 \times 10^{-4} \text{ Ci of } ^{90}\text{Sr} \\ &\quad 1.5 \times 10^{-4} \text{ Ci of } ^{137}\text{Cs} \\ &\quad 9.3 \times 10^{-5} \text{ Ci of } ^{239}\text{Pu} . \end{aligned}$$

3.6.1.3 Consequences

The 618-10 and 618-11 sites are located in the areas that are close to the 400 Area. Since the RADDIDOSE atmospheric dispersion data does not include the 400 Area, it was not used for this calculation. The doses are therefore determined by hand calculations. The dose is given by the following expression:

$$\text{Dose} = \sum (ST_i \times DCF_i) \times X/Q$$

where

ST_i = source term for each isotope
 DCF_i = dose conversion factor for each isotope.

The dose conversion factors (DCF) from ICRP-68, *Dose Coefficients for Intakes of Radionuclides by Workers—Replacement of ICRP Publication 61*, are used for the onsite calculation and DCFs from ICRP-71, *Age Dependent Doses to Members of the Public from Intake of Radionuclides Part 4 Inhalation Dose Coefficients*, are used for the offsite calculation. The $\sum(ST_i \times DCF_i)$ calculations are shown in Table 3-9. The factor of 3.7×10^{12} is included to convert from Sv/Bq to rem/Ci.

Table 3-9. Source Term Times Dose Conversion Factors.

Isotope	Source term (Ci)	ICRP-68 DCF (Sv/Bq)	ST \times ICRP-68 DCF $\times 3.7$ E12 (rem)	ICRP-71 DCF (Sv/Bq)	ST \times ICRP-71 DCF $\times 3.7$ E12 (rem)
Cs-137	1.5 E-04	6.7 E-09	3.72 E+00	4.6 E-09	2.55 E+00
Sr-90	1.5 E-04	3.2 E-08	1.78 E+01	3.74 E-08	2.08 E+01
Pu-239	9.3 E-05	3.2 E-05	1.10 E+04	5.0 E-05	1.72 E+04
Total			1.10 E+04		1.72 E+04

DCF = dose conversion factor.

ST = source term.

ICRP-68, 1994, *Dose Coefficients for Intakes of Radionuclides by Workers—Replacement of ICRP Publication 61*, Annals of the International Commission on Radiological Protection, Volume 24, Number 4, Elsevier Science, Tarrytown, New York.

ICRP-71, 1995, *Age Dependent Doses to Members of the Public from Intake of Radionuclides Part 4 Inhalation Dose Coefficients*, Annals of the International Commission on Radiological Protection, Volume 25, Number 3-4, Elsevier Science, Tarrytown, New York.

The breathing rate used for dose calculations is 3.33×10^{-4} m³/s. The overall 95th percentile X/Q for 300 Area meteorology for a receptor 100 m from the source is 0.031 s/m³. The 618-10 and 618-11 sites are located approximately 5 km from the Columbia River (Site boundary). The X/Q for the Site boundary is 2.28×10^{-5} s/m³ (see Section 3.5.2). The onsite and offsite doses are therefore

- Offsite

$$(1.72 \times 10^4)(3.33 \times 10^{-4})(2.28 \times 10^{-5}) = 1.31 \times 10^{-4} \text{ rem}$$

- Onsite

$$(1.10 \times 10^4)(3.33 \times 10^{-4})(0.0311) = 1.14 \times 10^{-1} \text{ rem}$$

3.6.1.4 Frequency

The release of contamination due to this type of activity is anticipated.

3.6.1.5 Risk Evaluation

The offsite dose is much less than 1 rem, and the onsite dose is much less than 25 rem (see Section 4.2). The consequences are therefore low. An anticipated event with low consequences is in Risk Bin III.

3.6.1.6 Controls

Risk Bin III events do not require safety-class or safety-significant controls to protect the public or the collocated workers. Risk to the workers doing the sampling will be minimized by radiological procedures.

3.6.2 Caisson Penetration with Fire

3.6.2.1 Scenario

The caisson penetration with fire accident is similar to the scenario described above except that the penetration of the caisson is assumed to induce a fire and explosion in the caisson. The fire and explosion could be caused by ignition of a flammable liquid or solid in a waste container, or ignition of hydrogen gas that had collected in a waste container. A fire in the caisson is not expected since only limited amounts of combustible materials are contained in a waste container located in a caissons. A penetration activity is unlikely to cause an ignition. No oxygen supply is available to support a large fire. The caissons are an open bottom unit with a piece of sheet metal covering the top on the pipe where they were loaded. These units were not constructed to contain gases or liquids if they spilled out of a waste container. Therefore an ignition of flammable gases causing a pressurization and possible fire is considered unlikely because of this type of construction and the location of the caissons in the ground. A fire and explosion due to waste or flammable gas ignition is, however, considered credible if a waste container containing flammable materials located inside the caisson is breached. The fire consequences has been evaluated.

The penetration of the caisson is assumed to induce an explosion in a can (used to package waste) in the caisson. This explosion is assumed to pressurize the caisson and cause a release of radioactive material. The material remaining in the caisson is assumed to be exposed to a fire and produce an additional release. The release is therefore a combination of an explosion and a fire.

3.6.2.2 Source Term

The MAR is the same as that assumed for the penetration accident in Section 3.6.1. The ARF for an internal explosion or rapid overpressurization in packaged waste is 1.0×10^{-3} (Table 2-4 of HNF-8739). The ARF for fire in combustible packaged waste is 5×10^{-4} and the RF is 1.0. The $ARF \times RF$ for heating noncombustible packaged waste is 6×10^{-5} . Fifty percent of the waste is assumed to be combustible and 50 percent is assumed to be noncombustible. This split of combustible or noncombustible waste was assumed because of the way waste was packaged for the VPUs and the caissons. The waste was packaged and transferred as remote-handled waste in cans or concrete lead-lined containers. The source term for the caisson accidents is 15 percent of the total inventory of the 618-11 site. The fire is assumed to affect the top 1 foot of the waste,

which is about 10 percent of the waste in the caisson. The explosion involves a single container and affects 5 percent of the waste in the caisson. The damage ratio is $0.1 \times 0.15 = 1.5 \times 10^{-2}$ for the fire (this includes both noncombustible and combustible materials) and $0.05 \times 0.15 = 7.5 \times 10^{-3}$ for the explosion. The combined damage ratio \times ARF \times RF is therefore given by the following:

$$\text{DR} \times \text{ARF} \times \text{RF explosion} + \text{DR} \times \text{ARF} \times \text{RF fire (combustibles and noncombustible)} \\ = (7.5 \times 10^{-3})(1 \times 10^{-3}) + (1.5 \times 10^{-2})[(0.5)(5 \times 10^{-4}) + (0.5)(6 \times 10^{-5})] = 1.17 \times 10^{-5}$$

The damage ratio \times ARF \times RF used in Section 3.6.1.2 is 1.5×10^{-7} . The other parameters in the dose calculation (e.g., X/Q, DCFs) are identical for the two scenarios. The relative doses are therefore $1.17 \times 10^{-5} / 1.5 \times 10^{-7} = 78$. The unmitigated doses for this scenario are 78 times the doses in Section 3.6.1.1.

3.6.2.3 Consequences

Unmitigated. Both the offsite and the onsite unmitigated doses are a factor of 78 larger than the doses calculated in Section 3.6.1.3. The doses are therefore

- **Offsite**

$$1.02 \times 10^{-2} \text{ rem}$$

- **Onsite**

$$8.9 \text{ rem .}$$

Mitigated. This mitigated analysis is provided to show that the above analysis is very conservative because any release that occurs from the caisson will follow a constrictive path to reach the surface. It is probable that either the probe will be in the hole or the dirt around the hole will collapse when the probe is removed. An explosion that pressurizes a container located inside a caisson will not have the energy to significantly shift the dirt so the leak path will have to follow the sample or drilling equipment that has been installed.. Even if a small hole is open, significant deposition will occur prior to the material released from the caisson reaching the surface. In HNF-4822, *Calculation Note - Consequences of a Fire in the Sorting and Repackaging Glovebox in Room 636 of Building 2736-ZB - Plutonium Finishing Plant*, a leak path factor (LPF) of .02 was calculated for a building with an active ventilation system with 12 air exchanges per hour. The LPF under forced ventilation is conservative compared to air movement expected for an underground chamber with a restricted access to the environment. Therefore an LPF of 0.02 is conservative based on the hole bored into the caisson for this fire in an underground unit. The mitigated doses (2.04×10^{-4} rem for offsite and 0.178 rem for onsite) are a factor of 50 lower than the unmitigated doses. Although the mitigated analysis is not credited it has been presented to provide the reader with additional information on the results of a penetration in a waste container located in a caisson that produces an explosion or fire.

3.6.2.4 Frequency

While the exact distribution of materials in the caisson is not well known, most waste is not expected to contain large quantities of flammable or explosive materials. It is therefore improbable that a penetration of the caisson would cause a fire or explosion. The oxygen supply to support a fire in the caisson is also limited. A fire and explosion in the caissons during sampling is therefore judged unlikely.

3.6.2.5 Risk Evaluation

The unmitigated offsite dose is much less than 1 rem and the onsite dose is less than 25 rem. The consequences are therefore low. An unlikely event with low consequences is in Risk Bin III. The 618-11 site is located adjacent to a public access area, Energy Northwest's Columbia Generating Station, which is located on the Hanford Site dose area. This area is not considered off site, and the unmitigated onsite dose is large enough that it is appropriate to consider administrative controls to minimize impact to this area.

3.6.2.6 Controls

Risk Bin III events do not require safety-class or safety-significant controls to protect the public or the collocated workers. Because the 618-10 and 618-11 site is located adjacent to a public access area, an Emergency Preparedness Program will be prepared and maintained during the sampling activities.

3.6.3 Release of Contaminated Soil

3.6.3.1 Scenario

Sampling operations involving drilling have the possibility of bringing contaminated soil to the surface during activities at a trench. It is possible that if the waste were exposed to the air, an airborne release could occur caused by a malfunction of the sampling equipment or operator error. The waste sample is then brought to the surface uncontained and results in an airborne release of radioactive material.

3.6.3.2 Source Term

It is expected that the release would affect only a small fraction of the waste since the drilling into a trench would affect only a small fraction of the buried waste. Three trenches are located in the 618-11 site (largest inventory) with a total volume of $3.375 \times 10^6 \text{ ft}^3$. Distributing the total inventory (10,000 g Pu) evenly through this volume would equal $2.96 \times 10^{-3} \text{ g Pu/ft}^3$. If all the inventory is assumed to be located in the trenches and the drill used to bore a hole hit some high-activity waste, a conservative assumption would be 1 g of plutonium brought to the surface of the trench. Item 3.5 of Attachment 3 of Roberson (2002) derived an ARF of 1×10^{-6} for a spill of soil from a height of 1 m. A spill of 1 m is assumed to envelope the release from inadvertent penetration of contaminated areas that brings contaminated soil to the surface and then spills it. The source term is therefore $(1)(1 \times 10^{-6}) = 1.0 \times 10^{-6} \text{ g}$. The release is a factor of 1,500 below the release given in Section 3.6.1.2.

3.6.3.3 Consequences

Both the offsite and the onsite doses are a factor of 1,500 smaller than the dose calculated in Section 1.3. The doses are therefore

- Offsite
8.73x 10⁻⁸ rem
- Onsite
7.6 x 10⁻⁵ rem .

3.6.3.4 Frequency

The event is anticipated.

3.6.3.5 Risk Evaluation

The offsite dose is five orders of magnitude less than 1 rem and the onsite dose is three orders of magnitude less than 25 rem. The consequences are therefore negligible.

3.6.3.6 Controls

Risk Bin III events do not require safety-class or safety-significant controls to protect the public or the collocated workers.

3.6.4 Sampling Pit Accident**3.6.4.1 Scenario**

The 618-10 and 618-11 waste sampling operations may include digging a pit to expose a trench. It is assumed that a backhoe or truck falls into the pit during the digging activities, impacting the waste in the trench. The pit is assumed to be approximately 8 ft in diameter and 6 ft deep. The potential for a fire exists because of fuel that is released when the vehicle falls or tips into the pit and because of the possibility of finding buried barrels of oil or other flammable liquids.

3.6.4.2 Source Term

Three trenches are located in the 618-11 site (largest inventory) with a total volume of $3.375 \times 10^6 \text{ ft}^3$. Distributing the total inventory (10,000 g Pu) evenly through this volume would equal $2.96 \times 10^{-3} \text{ g Pu/ft}^3$. The pit has a volume of $3.01 \times 10^2 \text{ ft}^3$ without subtracting the top 2 ft of overburden supplied in 1983. The source term that would be disturbed during this activity would be less than 1 g. The trenches were generally loaded with low-activity waste, which would make the above assumption conservative. There is some speculation that higher activity waste was deposited in the trenches in addition to contaminated equipment. To compensate for these additional unknowns, a factor of five was added to the source term number, for a bounding dispersible source term of 5 g Pu (0.31 Ci). The ARF for an impact of package waste is 1×10^{-3} and the RF is 0.1 (Table 5-4 of HNF-8739). The fuel from the backhoe is assumed to spill and ignite, heating the waste. The same damage ratio is assumed to apply to the heated waste. The waste located in the trench has been there since the early 1960s and has become part of the soil

matrix. The $ARF \times RF$ for heated combustible waste is 5×10^{-4} . The $ARF \times RF$ for heating noncombustible waste is 6×10^{-5} . Sixty-five percent of the waste is assumed to be combustible and 35 percent noncombustible (based on the information obtained from the Waste Receiving and Packaging facility on waste retrieved from burial grounds). The release due to the fire is $(0.65)(5 \times 10^{-4}) + (0.35)(6 \times 10^{-5}) = 3.46 \times 10^{-4}$. The $ARF \times RF$ for fire plus impact is $(3.46 \times 10^{-4}) + (1 \times 10^{-4}) = 4.46 \times 10^{-4}$.

3.6.4.3 Consequences

The dispersible material at risk is 5 g (0.31 Ci) of plutonium and the ARF is 4.4×10^{-4} . The release is therefore 2.23×10^{-4} g Pu or 1.38×10^{-4} Ci. The calculation in Section 3.6.1.3 assumed a release of 9.3×10^{-5} Ci of plutonium. The plutonium release for this accident is a factor of 1.49 higher ($1.38 \times 10^{-4} / 9.3 \times 10^{-5}$) than the release calculated in Section 3.6.1.3. The ^{137}Cs and ^{90}Sr would be released in the same fraction.

The doses are therefore

- Offsite
 $(1.49)(1.31 \times 10^{-4}) = 1.95 \times 10^{-4}$ rem
- Onsite
 $(1.49)(0.114) = 0.170$ rem .

3.6.4.4 Frequency

The impact event is anticipated.

3.6.4.5 Risk Evaluation

The offsite dose is much less than 1 rem and the onsite dose is less than 25 rem. The consequences are therefore low. An anticipated event with low consequences is in Risk Bin III.

3.6.4.6 Controls

Risk Bin III events do not require safety-class or safety-significant controls to protect the public or the collocated workers. This accident does pose a risk to the facility worker since a backhoe tipover could result in significant nonradiological injury to the operator or to people working in the vicinity of the backhoe. Risk will be minimized by adherence to industrial safety and radiological procedures.

4.0 SAFETY STRUCTURES, SYSTEMS, AND COMPONENTS

4.1 INTRODUCTION

The 618-10 site is located 4.3 mi (6.9 km) northwest of the 300 Area. It was constructed following concerns about high radiation levels in the nearby 618-2 Burial Ground adjacent to the 300 Area. The 618-10 site received low- to high-level radioactive waste from fission products and some plutonium-contaminated waste from operations in the 300 Area. The 618-10 burial ground operated from March 1953 to September 1963. The site was about 485 ft by 570 ft (147.8 m by 173.7 m) oriented northwest by southeast. According to drawings it contains 12 trenches ranging in size from 40 ft to 70 ft (12.1 m to 22.8 m) wide and from 50 ft to 320 ft (15.2 m to 91.4 m) long. The SSCs associated with the activities addressed in this BIO are the 94 VPUs (22 in. [56 cm] in diameter by 15 ft [4.6 m] long) and the sampling equipment.

The 618-11 site is located approximately 100 m west of Energy Northwest's Columbia Generating Station. This site received a variety of waste from the 300 Area operations. Low-level activity waste and large items were placed in the burial trenches. Some high-level waste, liquid waste, or plutonium-contaminated waste was placed in barrels and sealed with concrete. The intermediate- and high-level waste was disposed of in the VPUs or caissons. The 618-11 site operated from October 1962 to September 1967. The site contained three trenches 900 ft (270 m) long by 50 ft (15 m) wide. The SSCs associated with the activities addressed in this BIO are three to five caissons (8 ft [2.4 m] in diameter by 10 ft [3.0 m] long), 50 VPUs (22 in. [56 cm] in diameter by 15 ft [4.6 m]), and the sampling equipment.

4.2 REQUIREMENTS

The evaluation guideline is 25 rem total effective dose equivalent for the offsite public located on the Site boundary for an exposure duration of 2 hours. Any accident that produces an unmitigated release that exceeds this guideline criterion will require safety-class SSCs. Safety-class SSCs will be covered by TSRs. If the dose is between 1 rem and 25 rem, justification will be made for or against the need for safety-class SSCs and TSR controls. Offsite doses below 1 rem do not require safety-class SSCs.

Unmitigated accidents with unmitigated conditions for the offsite individual above Risk Class III will need specific controls to bring the risk class to a III or IV under mitigated conditions (the designated SSC performs intended safety function to reduce consequences). SSCs required to reach Risk Class III or lower for the maximum offsite individual for each accident will be designated as safety significant and covered by a TSR. These types of controls and, if required, SSCs are designated defense in depth. Designation of safety-significant SSCs is determined in the accident analysis with consideration for the safety of the facility worker.

4.3 SAFETY-CLASS STRUCTURES, SYSTEMS, AND COMPONENTS

Based on the results of the hazards and accident analyses presented in Section 3.6 (offsite doses less than 1 rem), no safety-class SSCs are associated with the 618-10 and 618-11 sites.

4.4 SAFETY-SIGNIFICANT STRUCTURES, SYSTEMS, AND COMPONENTS

Based on the results of the hazards and accident analysis presented in Section 3.6 (no controls to reduce an accident to a Risk Bin III or less), no safety-significant SSCs are associated with the 618-10 and 618-11 sites.

4.5 DEFENSE IN DEPTH

Based on the results of the accident analysis (no controls required to reduce risk to worker), the 618-10 and 618-11 sites do not have any defense-in-depth SSCs.

5.0 DERIVATIONS OF TECHNICAL SAFETY REQUIREMENTS

5.1 INTRODUCTION

The TSRs define acceptable conditions, safe boundaries, and management or administrative controls that ensure safe operation of a waste site. The TSRs reduce the potential risk to the onsite worker, the offsite public, and to the environment from uncontrolled releases of radioactive or hazardous materials.

5.2 REQUIREMENTS

The following documents contain the primary requirements used to derive the TSRs:

- 10 CFR 830, "Nuclear Safety Management"
 - Section 830.205, "Technical Safety Requirements"
- DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analysis*
 - Section 5.0, "Derivation of Technical Safety Requirements"
- DOE-STD-3011-2002, *Guidance for Preparation of Basis for Interim Operation Documents*
- HNF-PRO-700, *Safety Basis Development*.

5.3 TECHNICAL SAFETY REQUIREMENTS

The TSRs for the 618-10 and 618-11 sites are based on information from Chapters 3 and 4 and in accordance with HNF-PRO-700. HNF-PRO-700 states that development of TSRs shall be derived from the documented accident analysis. The accident analysis as described in Section 3.6 evaluates different accidents that are associated with sampling activities. TSRs are based on the magnitude of the uncontrolled releases:

- Release greater than or equal to safety-class criteria
- Releases greater than or equal to safety-significant criteria
- Releases that would require defense in depth.

The 618-10 site (Hazard Category 3) does not have any safety-class, safety-significant, or defense-in-depth SSCs.

The 618-11 site (Hazard Category 3) does not have any safety-class, safety-significant, or defense-in-depth SSCs.

For those events identified in the hazard analysis that require credited SMPs as controls, a clear link between the hazard and the SMP will be addressed.

5.4 TECHNICAL SAFETY REQUIREMENT DERIVATION

There are no Safety Limits, Limiting Control Settings, or Limiting Conditions of Operation TSRs for these waste sites. The 618-10 site is a Hazard Category 3 site and the 618-11 site final hazard category also is Hazard Category 3. The following Administrative Controls apply to these sites.

5.4.1 Organization and Responsibility

This Administrative Control is to ensure that lines of authority, responsibility, and communication are defined and maintained.

5.4.2 Emergency Preparedness

A program shall be established, implemented, and maintained to manage emergency preparedness at the 618-10 and 618-11 sites to address adjacent public access areas. The key elements for the Emergency Preparedness are:

- The EP program will provide for notification action to Energy Northwest and action to be taken in the event of a radionuclide release to the environment.
- The EP program will provide for notification of the Fire Protection Engineer to ensure appropriate steps are taken to minimize risk of fire prior to commencing work activities.

5.5 DESIGN FEATURES

Design features that are generically credited as an assumed initial system in the accident analysis include passive elements that provide a passive confinement boundary. Generically credited passive design features are included as required design features in the TSRs.

There are no design features credited in this BIO.

5.6 SAFETY MANAGEMENT PROGRAMS

The Fluor Hanford, Inc., programs that are in place to provide criteria, guidance, and site policy are captured in the HNF-11724 *Fluor Hanford Safety Management Program*. Inclusion of the SMPs in this BIO represents the contractor's commitment to ensure that all project activities are conducted safely through adequate implementation of the SMPs. Elements of the SMPs specifically credited as a preventive or mitigative feature in the hazards and accident analysis presented in Chapter 3 are addressed in the TSR document.

DOE, Richland Operations Office, and Fluor Hanford, Inc., with its major subcontractors, agree that all work performed under the Project Hanford Management Contract is to be done in accordance with a single, integrated environment, safety, and health management system plan.

This plan requires the integration of hazard identification, hazard analysis, and hazard control into facility operations and requires feedback for continuous improvement.

6.0 PREVENTION OF INADVERTENT CRITICALITY

6.1 INTRODUCTION

The 618-11 site had an initial hazard categorization of Hazard Category 2 Nuclear Facility. An estimated 10,000 g of plutonium is distributed in 3 trenches, 50 VPUs, and 3 to 5 caissons at the 618-11 site (see Appendix A).

The 618-10 site has a hazard categorization of Hazard Category 3. An estimated 200 g of plutonium is distributed in 12 waste trenches and 94 VPUs at the 618-10 site (see Appendix A).

6.2 REQUIREMENTS

As stated in DOE-STD-3009-94, Hazard Category 3 facilities, by definition, do not contain sufficient fissile material to present a criticality hazard. This chapter is, therefore, not applicable to Hazard Category 3 facilities. Inventory limits, if required, specified in the TSR will control the amount of inventory. This chapter does apply to Hazard Category 2 facilities with inventories of fissile material sufficient to present an inadvertent criticality hazard.

6.3 CRITICALITY CONCERNS AND CONTROLS

HNF-7098, *Criticality Safety Program*, describes the Fluor Hanford, Inc., program to protect the employees and the general public from undue hazards that may arise from the presence of fissionable materials.

This BIO is limited to surveillance and maintenance, sampling and characterization. The burial sites have been stabilized and no longer receive or are permitted to receive fissionable material. Disturbance of the waste will be limited to characterization activities that penetrate the burial ground overburden and potentially penetrate the waste, insert detection equipment and /or sampling equipment, and remove samples. The penetration of the burial site will utilize equipment that forces a hollow shaft into the waste. This is a dry process that does not introduce a water moderator into the waste.

The 618-10 site contains 200 g of plutonium, which is less than half of a minimum critical mass (530 g) for a spherical, optimally water-moderated, and fully reflective system. Therefore no additional analysis is required.

The 618-11 site has a conservative inventory estimate of 10 kg of plutonium (Appendix A). The 10 kg value is considered a maximum value, as the estimated range is 1 kg to 10 kg. This estimate does not include any uranium. If during characterization activities, kilogram quantities of uranium with an enrichment of greater than 1 wt% were found, a criticality evaluation would need to be extended to uranium. The accident analysis developed a source term for the caissons by neglecting the inventory in the trenches and dividing the site inventory by the volume of the 50 VPUs and 3 caissons. This results in 15 percent of the inventory located in each caisson, which translates to 1,500 g of plutonium per caisson.

The trenches received the low- to moderate-activity radioactive waste packaged in non-shielded containers; the VPUs and caissons received the moderate- to high-activity radioactive waste in metal or concrete lead-lined containers. The 12 V-shaped trenches are 900 ft long, 50 ft wide, and 25 ft deep; therefore, the amount of waste going to the trenches would be many times that going to the VPUs and caissons. Although no numeric analysis of volumes can be made and the trenches received the lower activity items, it is a reasonable assumption that dividing up the maximum estimate of plutonium sent to the 618-11 site among the VPUs and caissons would give a conservative value for their inventory.

An inventory of 1,500 g plutonium per caisson is approximately three times the minimum critical mass (530 g) for a spherical, optimally water-moderated, and fully reflective system. However, the material in the caissons is dispersed over a large waste matrix that does not approach an optimized system. Although the material is in a waste matrix that has a substantial portion attributed to the metal containers used to package the waste, it can be conservatively assumed that the containers have degraded to the extent that much of the material could be redistributed in the caisson. The waste matrix is assumed to be glass, steel, cloth, plastic sheeting, and other used items from hot cell operations with no solid plastic, beryllium, graphite, or other highly effective moderators in significant fractions of the mass of plutonium present. Records indicate that only small quantities of these materials (contaminated laboratory equipment) may be present. These more effective moderator materials are not present in quantities that would pose a problem.

If the plutonium is assumed to be distributed roughly uniformly, the areal density would be approximately $3.2 \times 10^{-2} \text{ g/cm}^2$. The "single parameter limits for uniform aqueous solutions of fissile nuclides" in ANSI/ANS-8.1-1983, *Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors*, for plutonium solutions provides a minimum areal density of $2.5 \times 10^{-1} \text{ g/cm}^2$. This comparison shows that if all the plutonium were washed to a slab at the bottom of the caissons, there would be only an eighth as much plutonium as is needed for a critical configuration, which means that the plutonium in the caisson would have to concentrate in one-eighth of the caisson floor area for a critical configuration to be possible.

Some materials, such as dry silicon dioxide, can support a criticality at a lower concentration (tens of kilograms of plutonium). However, it is not considered credible to have enough plutonium mixed with just sand in typical Hanford Site soil. Considering the conservative assumptions of the plutonium inventory, the distribution of the plutonium in the burial sites, and the poorly optimized configuration of the waste matrix, a criticality in the caisson is not credible.

For the purpose of the criticality analysis, the accident involving a penetration of a caisson and a fire or explosion (see Section 3.6.2) is used. The equipment is removed from the caisson and the soil does not cave in on the hole. The fire department responds to the fire and water is added to the caisson. The water addition is assumed to wash fissionable material from the current waste matrix to an optimally moderated slab located in a layer in the bottom of the caisson. The soil is assumed to be a typical Hanford Site soil and not pure, dry sand. A conservative assumption for the fraction of plutonium that would wash to the bottom of a caisson would be 50 percent or 750 g of plutonium. Figure III.A.6(97)-4 in ARH-600, *Criticality Handbook*, shows that the

minimum critical mass of plutonium for a fully water-reflected sphere of a plutonium–water mixture in soil is 1,700 g of plutonium. This mass is based on the plutonium having 3 wt% ^{240}Pu content. This is a reasonable assumption because almost all plutonium was made with more than 3 wt% ^{240}Pu . This 1,700-g value is for soil with a 40 vol% interstitial space that can be filled by a plutonium–water mixture. The estimated available plutonium is less than 45 percent of the minimum critical mass as required by HNF-7098.

A washed-down deposit in the soil is not expected to be spherical or fully water reflected. The minimum critical mass requires the concentration of plutonium in water to be 19 g Pu/L for the 40 vol% case. The critical sphere has a volume of 89 L. At larger and smaller concentrations, more plutonium is needed for a critical configuration. Based on this data, the worst-case scenario is adequately subcritical. The plutonium in the caissons, VPUs, and trenches does not pose a criticality hazard. A criticality in the caisson is not credible.

Based on the analysis discussed above, the mass of plutonium required to be in a caisson and involved in a water addition and reconfiguration would need to be more than one-third of all the material in all the caissons and VPUs at an upper bound waste site estimate. This is the best data available prior to characterization. It is concluded, based on this bounding assumed inventory, that criticality is not credible and the waste matrices in the 618-10 and 618-11 sites constitute a limited control facility.

Sampling may result in the removal of small quantities of fissionable material from a caisson, VPU, or trench. Based on the minimal volume retrieved during sampling activities, a sample is expected to result in only gram quantities removed or disturbed. Greater quantities would only be removed during activities that are currently not covered in this BIO.

One-third of a minimum critical mass, 177 fissile-gram-equivalent, is the definition of an isolated facility according to HNF-7098. Samples retrieved from the 618-10 and 618-11 sites may be managed as an isolated facility in accordance with HNF-7098 until it can be demonstrated that the samples contain only exempt quantities or they are shipped from the sites.

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APPENDIX A
CALCULATION SHEET

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APPENDIX A

Bechtel Hanford, Inc.

CALCULATION SHEET

Originator M. F. Maxson Date 4/18/01 Calc. No. 0300X-CA-N0007 Rev. A
 Project RAWD Job No. 22192 Checked [initials] Date 4-18-01
 Subject Preliminary Estimate of Total Radionuclide Inventory in 618-10 and 618-11 Waste Sites
 Sheet No. 1 of 4

1.0 INTRODUCTION

The 618-10 (a.k.a., 300 North Solid Waste Burial Ground) and the 618-11 (a.k.a., Y Burial Ground, 300 Wye Burial Ground) waste sites both received a broad spectrum of low to high-level solid radioactive wastes. The low-level wastes were buried in trenches, while the medium and high-level wastes were primarily buried in caissons or buried pipe facilities. The wastes were primary contaminated with fission products and plutonium. This calculation estimates the preliminary total radiological inventory contained within the 618-10 and 618-11 waste sites to support the development of a safety analysis strategy for them. The calculation also compares the estimated total inventories to the DOE-STD-1027-92 Attachment 1, Table A.1, category 2 and category 3 Threshold Quantities (TQs).

2.0 SUMMARY OF RESULTS

The 618-10 and the 618-11 waste site are both estimated to contain about 2×10^3 curies of beta-gamma emitting radionuclides, which are assumed to be present in equal amounts of strontium-90 and cesium-137. In addition, the 618-10 and 618-11 waste sites are estimated to contain about 2×10^2 and 1×10^4 grams of plutonium, respectively. Consequently, the estimated total radionuclide inventories of the 618-10 and 618-11 waste sites exceed the category 3 and category 2 TQ, respectively.

3.0 RADIONUCLIDE INVENTORY

The historical data for the 618-10 and 618-11 waste sites generally report the radionuclide inventory in terms of total beta-gamma (in curies) and total plutonium (in grams). The one exception to this approach is found in DOE 1987, Table A.17, which lists the total inventories (in curies) of nine separate radionuclides in the "618" waste sites (i.e., 618-1, 618-2, and 618-11). The nine radionuclides listed are cobalt-60, strontium-90, cesium-137, plutonium-238, -239, -240, -241, -242, and americium-241. DOE 1987, Table A.13, provides an estimate of the total plutonium inventory (in grams) contained within the 618-11 waste site, which is consistent with the other references evaluated for this calculation.

The total inventory of beta-gamma radionuclides in each of the two waste sites is generally estimated to be about 2×10^3 Ci. DOE 1987 reports a cobalt-60 inventory for the "618" waste

Bechtel Hanford, Inc.

CALCULATION SHEET

Originator M. F. Maxson ^{mfam} Date 4/18/01 Calc. No. 0300X-CA-N0007 Rev. A
 Project RAWD Job No. 22192 Checked js Date 4-18-01
 Subject Preliminary Estimate of Total Radionuclide Inventory in 618-10 and 618-11 Waste Sites

Sheet No. 2 of 4

sites that is an order of magnitude smaller than the strontium-90 and cesium-137 inventory. Cobalt-60 has a relatively short half-life (5.3 years) compared to strontium-90 (28.8 years) and cesium-137 (30.2 years). Consequently, it is reasonable to assume that cobalt-60 is a negligible contributor to the current beta-gamma inventory of the 618-11 waste site. Since the types of waste sent to the 618-10 waste site are reported to be similar to those sent to the 618-11 waste site (e.g., solid waste from the destructive metallurgical testing of reactor fuels), it is reasonable to assume that the cobalt-60 inventory at the 618-10 waste site is also negligible. Consequently, it is reasonably conservative to assume that the beta-gamma inventory of the two sites is split equally between strontium-90 and cesium-137. This implies that the estimated total inventory of each of these radionuclides is 1×10^3 Ci in both the 618-10 and the 618-11 waste site.

DOE 1987, Table A.17, identifies five isotopes of plutonium and americium-241 in the radionuclide inventory of the "618" waste sites, while the other references evaluated simply provide the total mass of plutonium believed to have been buried in the 618-11 site. DOE 1987, as mentioned previously, also estimates the total mass of plutonium in the 618-11 waste site. The references evaluated for the 618-10 waste site simply provide the total mass of plutonium believed to have been buried at the site. For simplicity and conservatism, it is assumed that the total mass of plutonium present in each of the two waste sites is in the form of plutonium-239, which has a specific activity of 6.22×10^{-2} curies/gram (BHI 2000).

The estimated maximum plutonium inventory contained within the 618-10 waste site ranges from 0.1 to 1 kilogram. The most definitive estimate is made in Rockwell 1987, which states that the plutonium quantity to be used for the site is 200 grams. The total plutonium inventory for the 618-11 waste site is estimated to range from 1 to 10 kilograms, with 10 kilograms generally cited as a maximum quantity. Therefore, the estimated total plutonium inventories of the 618-10 and 618-11 waste sites are 200 grams and 10 kilograms, respectively. Based on a specific activity of 6.22×10^{-2} curies/gram for plutonium-239 as reported above, the estimated total plutonium inventory of the 618-10 and the 618-11 waste sites is 12.5 curies and 622 curies, respectively.

The preliminary total radionuclide inventories for the 618-10 and 618-11 waste sites are identified in Table 1 and Table 2, respectively. The category 2 and category 3 TQs for each radionuclide, as identified in DOE 1992, are also listed in the tables. Table 1 and Table 2 show the calculated ratio of each radionuclide to its category 2 and category 3 TQ value, and also show the calculated sum-of-ratios value for the 618-10 and 618-11 waste sites, respectively.

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CALCULATION SHEET

Originator M. F. Maxson Date 4/18/01 Calc. No. 0300X-CA-N0007 Rev. A
 Project RAWD Job No. 22192 Checked [Signature] Date 4-18-01
 Subject Preliminary Estimate of Total Radionuclide Inventory in 618-10 and 618-11 Waste Sites
 Sheet No. 3 of 4

Table 1. Estimated total radionuclide inventory in the 618-10 waste site.

Radionuclide	Total Inventory, Ci	DOE-STD-1027-92 Attachment 1, Table A.1			
		Category 2 TQ, Ci	Ratio	Category 3 TQ, Ci	Ratio
Sr-90	1.0E+03	2.2E+04	4.6E-02	1.6E+01	6.3E+01
Cs-137	1.0E+03	8.9E+04	1.1E-02	6.0E+01	1.7E+01
Pu-239	1.25E+01	5.6E+01	2.2E-01	5.2E-01	2.4E+01
		Sum of Ratios	2.8E-01	Sum of Ratios	1.0E+02

Table 2. Estimated total radionuclide inventory in the 618-11 waste site.

Radionuclide	Total Inventory, Ci	DOE-STD-1027-92 Attachment 1, Table A.1			
		Category 2 TQ, Ci	Ratio	Category 3 TQ, Ci	Ratio
Sr-90	1.0E+03	2.2E+04	4.6E-02	1.6E+01	6.3E+01
Cs-137	1.0E+03	8.9E+04	1.1E-02	6.0E+01	1.7E+01
Pu-239	6.22E+02	5.6E+01	1.1E+01	5.2E-01	1.2E+03
		Sum of Ratios	1.1E+01	Sum of Ratios	1.3E+03

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CALCULATION SHEET

Originator ^{mgm} M. F. Maxson Date 4/18/01 Calc. No. 0300X-CA-N0007 Rev. A
 Project RAWD Job No. 22192 Checked gmx Date 4-18-01
 Subject Preliminary Estimate of Total Radionuclide Inventory in 618-10 and 618-11 Waste Sites
 Sheet No. 4 of 4

4.0 CONCLUSION

The estimated total radiological inventory for the 618-10 waste site indicates a preliminary hazard classification (PHC) of hazard category 3 would be appropriate if segmentation is not possible. The estimated total radiological inventory for the 618-11 waste site indicates a PHC of hazard category 2 would be appropriate if segmentation is not possible.

5.0 REFERENCES

ARH, 1972, "Preliminary Problem Definition Decommissioning the Hanford Site," ARH-2164, Atlantic Richfield Hanford Company, Richland, Washington.

BHI, 2000, "Criticality Safety Reviews," BHI-DE-01, EDPI-4.35-01, Bechtel Hanford, Inc., Richland, Washington.

DOE, 1987, "Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes," DOE/EIS-0113, Vol. 2, U.S. Department of Energy, Washington, D.C.

DOE, 1992, *Hazard Classification and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports*, DOE-STD-1027-92, Change Notice No. 1, U.S. Department of Energy, Washington, D.C.

Rockwell, 1987, "Amount of Plutonium in Waste Sites 618-1, 618-2, 618-10, 618-11," Internal Letter No. 65662-87-016, Rockwell International, Richland, Washington.

WHC, 1993, "Miscellaneous Information Regarding Operation and Inventory of 618-11 Burial Ground," WHC-MR-0416, Westinghouse Hanford Company, Richland, Washington.

APPENDIX B
FIRE HAZARDS ANALYSIS

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APPENDIX B

FIRE HAZARDS ANALYSIS

The fire hazards analysis for the 618-10 and 618-11 sites is found in CP-15164, *Fire Hazards Analysis 618-10 and 618-11 Waste Burial Grounds*.

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APPENDIX C
PRELIMINARY HAZARDS ANALYSIS CHECKLIST

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APPENDIX C

PRELIMINARY HAZARDS ANALYSIS CHECKLIST

Hazard Evaluation for 618-10- and 618-11 Site Activities

What-If Format **Facilitator: John Van Keuren**
December 19, 2002 **Team: Dale Dutt, Alan Horner, Larry Hulstrom, Paul Macbeth, Paul Polus, Christine Webb, John Van Keuren, Dale West, Steve Landsman, John Cornelison, Jim Steffen, Frank Roddy**

Table C-1. "What-If" Results. (3 sheets)

What If	Hazard/ Consequence	Engineered/Administrative Feature	Comments
Trench subsidence occurs	Airborne release of radioactive or toxic materials Shock-sensitive chemical explosion Vehicle tip over Concentrate/reconfigure fissile material	Engineered: Soil overburden Administrative: Vehicle access control Ongoing surveillances	
Vehicle catches fire	Initiates a brush fire Fire fighting introduces water in a concentrated area Criticality due to water moderation	Engineered: Administrative: Fire department	
Refueling truck catches fire	Fire may be more intense but hazard is similar to vehicle fire	Engineered: Administrative: Fire department	No radiation release
Airplane crash		Engineered: Administrative:	See Roberson (2002)

Table C-1. “What-If” Results. (3 sheets)

What If	Hazard/ Consequence	Engineered/Administrative Feature	Comments
Probe/drill encounters waste	<p>Collapse of a caisson</p> <p>Probe encounters a pressurized caisson or waste container, which disturbs reactive material</p> <p>A fire is started in the caisson, VPU, or trench</p> <p>Probe brings radioactive or toxic contamination to the surface</p> <p>Radiation shine</p>	<p>Engineered:</p> <p>Soil overburden</p> <p>Probe/drill designed to prevent fire</p> <p>Geophysical surveys guide operations</p> <p>Administrative:</p> <p>Contamination control</p> <p>Radiation Protection Program</p> <p>Pre-fire Plan</p>	Hole from probe will probably collapse and fill after removal of probe
Geo-probe “pipe” is left in place to deploy instruments	<p>Pipe provides a radioactive or toxic contamination release path</p> <p>Pipe creates path for water entry to caisson, VPU</p> <p>Pipe provides radiation shine path</p>	<p>Engineered:</p> <p>Capped “pipe”</p> <p>Administrative:</p> <p>Radiation Protection Program</p>	
Accident occurs at adjacent facility	Sudden, unplanned interruption of work	<p>Engineered:</p> <p>Administrative:</p> <p>Interface with adjacent facilities</p> <p>Personnel training</p>	No obvious hazard with unplanned stopping of work
Individuals performing work next to the site inadvertently intrude into site disturbing waste	Release of radioactive or toxic contamination	<p>Engineered:</p> <p>Fenced site</p> <p>Administrative:</p> <p>Work planning</p>	

Table C-1. "What-If" Results. (3 sheets)

What If	Hazard/ Consequence	Engineered/Administrative Feature	Comments
Earthquake (or other natural phenomena) occurs while driving the Geo-probe	Release of radioactive or toxic contamination Caisson collapses	Engineered: Soil overburden Administrative: Capped intrusive devices	
Waste generated by site activities is impacted by vehicle or fire	Release of radioactive or toxic contamination Worker exposure	Engineered: Waste container (drum) design Administrative: Handling/Packaging/ Storage procedures	
Drilling impacts underground radioactive waste, electric or gas lines	Not credible	Engineered: Administrative:	No underground lines in the burial grounds

Roberson, J. H., 2002, *Hazard Categorization of EM Inactive Waste Sites as Less Than Hazard Category 3* (Memorandum for Distribution, September 17), U.S. Department of Energy, Washington, D.C.

Table A-2. Hazard Identification Checklist and Energy Designators for 618-10 and 618-11 Waste Sites. (5 sheets)

LOTE Low Thermal Energy	AE Acoustic Energy	BIO Biological
<input type="checkbox"/> 1 Cryogenic Systems	X 1 Equipment/Platform Vibration	X 1 Animal/Insect Hazard
<input type="checkbox"/> 1.1 Freeze Seal Equipment	<input type="checkbox"/> 2 Equipment Rooms	X 1.1 Dead Animals
X 1.2 Liquid N ₂ in Dewars	<input type="checkbox"/> 2.1 Motor Rooms	X 1.2 Animal Droppings
<input type="checkbox"/> 1.3 Liquid N ₂ in Tanks	<input type="checkbox"/> 2.2 Pump Rooms	X 1.3 Animal Bites
<input type="checkbox"/> 1.4 Liquid N ₂ Production	<input type="checkbox"/> 2.3 Fan Rooms	X 1.4 Insect Bites
<input type="checkbox"/> 1.5 Other Cryogenic Systems	<input type="checkbox"/> 2.4 Compressor Rooms	X 1.5 Insect Stings
	<input type="checkbox"/> 2.5 Other Equipment Rooms	<input type="checkbox"/> 2 Plant Hazards
<input type="checkbox"/> 2 Low Ambient Temperatures		X 2.1 Allergens
<input type="checkbox"/> 2.1 Loss of HVAC [system impacts]	<input type="checkbox"/> 3 Decontamination & Size Reduction Tools	<input type="checkbox"/> 2.2 Toxins
<input type="checkbox"/> 2.2 Loss of HVAC [worker impacts]	<input type="checkbox"/> 3.1 Cutting Devices	<input type="checkbox"/> 3 Disease Related Hazards
<input type="checkbox"/> 2.3 Freezers/Chillers	<input type="checkbox"/> 3.2 Decontamination Devices	<input type="checkbox"/> 3.1 Bacteria
<input type="checkbox"/> 2.4 Other Low Temperatures	<input type="checkbox"/> 3.3 Abrading Devices	<input type="checkbox"/> 3.2 Viruses
	<input type="checkbox"/> 3.4 Other AE Tools	<input type="checkbox"/> 3.3 Sewage
<input type="checkbox"/> 3 Other LOTE Hazards	<input type="checkbox"/> 4 Other AE Hazards	<input type="checkbox"/> 3.4 Blood/Body Fluids
		<input type="checkbox"/> 3.5 Medical Waste
		<input type="checkbox"/> 4 Other BIO Hazards
NPH Natural Phenomena	OTH Other	KE Kinetic Energy
1 Earthquakes	<input type="checkbox"/> 1 Inert/Low O ₂ Atmosphere	X 1 Vehicle/Transport Devices in Motion
X 2 Natural Radiation	X 1.1 Dust [breathing]	<input type="checkbox"/> 1.1 Rail Cars/Trains
X 3 Lightning	<input type="checkbox"/> 1.2 N ₂ /He Atmosphere	<input type="checkbox"/> 1.2 Excavators/Backhoes
X 4 Solar/Heat Wave	<input type="checkbox"/> 1.3 Confined Spaces	<input type="checkbox"/> 1.3 Cranes/Crane Loads
X 5 Range Fire	<input type="checkbox"/> 1.3.1 Tanks	X 1.4 Trucks/Cars
X 6 Dust/Sand	<input type="checkbox"/> 1.3.2 Basins	<input type="checkbox"/> 1.5 Forklifts/Loaders
X 7 Fog	<input type="checkbox"/> 1.3.3 Manholes	<input type="checkbox"/> 1.6 Conveyors
X Heavy Rain	<input type="checkbox"/> 1.3.4 Pits	X 1.7 Man-Powered Devices in Motion
X 8.1 Flooding [from rain]	X 1.4 Trench/Excavation Collapse	<input type="checkbox"/> 1.7.1 Hoists
<input type="checkbox"/> 8.2 Sediment Transport	<input type="checkbox"/> 1.5 Water in Confined Space	X 1.7.2 Carts/Dollies
X 9 Hail	<input type="checkbox"/> 1.6 Other Low O ₂ Atmospheres	X 1.8 Other Device in Motion ___DRILL RIG___
X 10 Low Temperatures		<input type="checkbox"/> 2 Loaded Transports in Motion
X 11 Freeze	<input type="checkbox"/> 2 Inadequate Visibility	<input type="checkbox"/> 2.1 Crane Loads [loaded]
X 12 Heavy Snow	<input type="checkbox"/> 2.1 Respirator Fogging	X 2.2 Trucks [loaded]
X 13 High Winds	X 2.2 Dust [visibility]	<input type="checkbox"/> 2.3 Forklifts [loaded]
<input type="checkbox"/> 14 Tornadoes	<input type="checkbox"/> 2.3 Glare	<input type="checkbox"/> 2.4 Conveyors [loaded]
<input type="checkbox"/> 15 Volcanoes	<input type="checkbox"/> 2.4 Other Impaired Visibility	<input type="checkbox"/> 2.5 Loaded Man-Powered Transports in Motion
X 16 Volcanic Ash	X 3 External/Offsite Event	<input type="checkbox"/> 2.5.1 Hoists [loaded]
<input type="checkbox"/> 17 Other NPH	X 3.1 Aircraft Crash	<input type="checkbox"/> 2.5.2 Pallet Jacks [loaded]
	<input type="checkbox"/> 3.2 Offsite Transportation Accident	<input type="checkbox"/> 2.5.3 Carts/Dollies [loaded]
	<input type="checkbox"/> 3.3 Offsite Explosion	<input type="checkbox"/> 2.6 Other Transport in Motion
	X 3.4 Major Fire	
	<input type="checkbox"/> 3.5 Reservoir Failure	<input type="checkbox"/> 3 Decontamination & Size Reduction Tools
	<input type="checkbox"/> 3.6 Other External Event	<input type="checkbox"/> 3.1 Impact Tools
	X 4 Unknown Material	<input type="checkbox"/> 3.2 Projectile Tools
	X 5 Unknown Configuration	<input type="checkbox"/> 3.3 Other KE Tools
	<input type="checkbox"/> 6 Other OTH Hazards	
		<input type="checkbox"/> 4 Relief Valve Blow-down
		<input type="checkbox"/> 5 Other KE Hazards

Table A-2. Hazard Identification Checklist and Energy Designators for 618-10 and 618-11 Waste Sites. (5 sheets)

LOEE Loss of Electrical Energy	CM Chemical Materials	CE Chemical Energy
<input checked="" type="checkbox"/> 1 Loss of Powered Equipment <input type="checkbox"/> 1.1 Motor Stoppage <input type="checkbox"/> 1.2 Pump Stoppage <input type="checkbox"/> 1.3 Fan Stoppage in Areas with Differential Pressure <input type="checkbox"/> 1.3.1 Flow Reversal <input type="checkbox"/> 1.3.2 Supply Fan Pressurization <input type="checkbox"/> 1.3.3 Static Air Situation <input type="checkbox"/> 1.4 Fan Stoppage in Ventilated Areas <input type="checkbox"/> 1.4.1 Accumulation of Hazardous Vapors <input type="checkbox"/> 1.4.2 Accumulation of Asphyxiants <input type="checkbox"/> 1.4.3 Accumulation of Flammable Gases <input type="checkbox"/> 1.5 Compressor Stoppage <input type="checkbox"/> 1.5.1 Loss of Air [dry-pipe] <input type="checkbox"/> 1.5.2 Loss of Air [no inert] <input type="checkbox"/> 1.5.3 Reduced PPE Pressure <input type="checkbox"/> 1.6 Loss of Heaters <input type="checkbox"/> 1.6.1 System Freeze Impacts <input type="checkbox"/> 1.6.2 Worker Freeze Impacts <input type="checkbox"/> 1.7 Loss of Coolers/Chillers <input type="checkbox"/> 1.7.1 System Overheat Impacts <input type="checkbox"/> 1.7.2 Worker Overheat Impacts <input type="checkbox"/> 1.8 Misdirected Flow due to Loss of Valves/Dampers <input checked="" type="checkbox"/> 1.9 Loss Instrumentation <input type="checkbox"/> 1.10 Other Equipment Loss <input checked="" type="checkbox"/> 2 Inadequate Light/Illumination <input type="checkbox"/> 2.1 Operations Impacts <input type="checkbox"/> 2.2 Worker Impacts <input type="checkbox"/> 3 Loss of Batteries/Direct Current Systems <input type="checkbox"/> 4 Other LOEE Hazards	<input checked="" type="checkbox"/> 1 Toxins <input checked="" type="checkbox"/> 1.1 Hepatotoxins [Carbon Tetrachloride] <input type="checkbox"/> 1.2 Nephrotoxins [Chloroform] <input checked="" type="checkbox"/> 1.3 Neurotoxins [Mercury] <input checked="" type="checkbox"/> 1.4 Reproductive Toxins [Lead] <input type="checkbox"/> 1.5 Toxic Agents [Strychnine] <input checked="" type="checkbox"/> 1.6 Agents that Attack the Lungs [Asbestos] <input checked="" type="checkbox"/> 1.6.1 Ceiling Tiles/Insulation <input checked="" type="checkbox"/> 1.7 Agents that Attack the Skin [Acetone] <input type="checkbox"/> 1.8 Agents that Attack the Eyes [Organic Solvents] <input type="checkbox"/> 1.9 Agents that Attack the Mucous Membranes [Ammonia] <input type="checkbox"/> 1.10 Agents that Attack the Blood [Carbon Monoxide/ Cyanides] <input checked="" type="checkbox"/> 1.11 Carcinogens [Carbon Tetrachloride, PCBs] <input checked="" type="checkbox"/> 1.12 Sensitizers [Beryllium/Epoxy Resins] <input type="checkbox"/> 1.13 Irritants [Calcium Chloride] <input type="checkbox"/> 1.14 Pesticides/Insecticides <input checked="" type="checkbox"/> 1.15 Herbicides <input type="checkbox"/> 1.16 Other Toxins <input type="checkbox"/> 2 Asphyxiants <input type="checkbox"/> 3 Miscellaneous Chemicals/Groups <input checked="" type="checkbox"/> 3.1 Hazardous Wastes [RCRA, TSCA] <input type="checkbox"/> 3.2 Creosote <input type="checkbox"/> 3.3 Other Miscellaneous Chemicals <input checked="" type="checkbox"/> 4 Other CM Hazards	<input checked="" type="checkbox"/> 1 Oxidizers <input type="checkbox"/> 1.1 Organic Peroxides <input checked="" type="checkbox"/> 1.2 Corrosives/Acids/Reagents/ Bleaches [in use] <input checked="" type="checkbox"/> 1.3 Residual Corrosives/Acids <input type="checkbox"/> 1.4 Battery Banks <input type="checkbox"/> 1.5 Other Oxidizers <input checked="" type="checkbox"/> 2 Reactives <input checked="" type="checkbox"/> 2.1 Water Reactives [Sodium] <input checked="" type="checkbox"/> 2.2 Shock Sensitive Chemicals [Nitrates] <input checked="" type="checkbox"/> 2.3 Peroxides/ Superoxides/Ethers <input checked="" type="checkbox"/> 2.4 Explosive Substances <input type="checkbox"/> 2.4.1 Electric Squibs <input type="checkbox"/> 2.4.2 Dynamites/Caps/ Primer Cord <input type="checkbox"/> 2.4.3 Dusts [explosive] <input type="checkbox"/> 2.5 Other Reactives <input checked="" type="checkbox"/> 3 Other Chemical Energy Hazards <input checked="" type="checkbox"/> 3.1 Corrosion/Oxidation [rust] <input type="checkbox"/> 3.2 Bonding Agents <input type="checkbox"/> 3.2.1 Sealants/Fixatives <input type="checkbox"/> 3.2.2 Epoxies/Adhesives <input type="checkbox"/> 3.3 Refrigerants/Coolants [Propylene Glycol] <input type="checkbox"/> 3.4 Water Treatment Products <input checked="" type="checkbox"/> 3.5 Decontamination Chemicals <input checked="" type="checkbox"/> 3.6 Miscellaneous Laboratory Chemicals <input checked="" type="checkbox"/> 3.7 Soil/Air/Water Reactions [Buried Materials] <input checked="" type="checkbox"/> 4 Incompatible Wastes <input type="checkbox"/> 5 High Temperature Wastes <input type="checkbox"/> 6 Other CE Hazards

Table A-2. Hazard Identification Checklist and Energy Designators for 618-10 and 618-11 Waste Sites. (5 sheets)

ME Mechanical Energy	TP Thermal Potential Energy	EE Electrical Energy
<input checked="" type="checkbox"/> 1 Transverse [single direction] Motion Devices <input type="checkbox"/> 1.1 Forklift Tines [puncture] <input checked="" type="checkbox"/> 1.2 Piston Compressors [crush] <input checked="" type="checkbox"/> 1.3 Presses [crush] <input checked="" type="checkbox"/> 1.4 Pinch Points [pinch] <input checked="" type="checkbox"/> 1.5 Sharp Edges/Objects [cut] <input checked="" type="checkbox"/> 1.6 Drills [puncture] <input type="checkbox"/> 1.7 Sanders/Brushes [wear] <input type="checkbox"/> 1.8 Shears/Pipe Cutters [shear] <input type="checkbox"/> 1.9 Grinders [crush/pinch/shear] <input type="checkbox"/> 1.10 Other Transverse Motion <input type="checkbox"/> 2 Reciprocating [back and forth] Motion Devices <input type="checkbox"/> 2.1 Vibration [wear] <input type="checkbox"/> 2.2 Saws [cut] <input type="checkbox"/> 2.3 Other Reciprocating Motion <input type="checkbox"/> 3 Circular Motion Devices <input type="checkbox"/> 3.1 Belts/Hoist Cables [pull/wrap] <input type="checkbox"/> 3.2 Bearings/Shafts [wrap] <input type="checkbox"/> 3.3 Gears/Couplings [pull] <input checked="" type="checkbox"/> 3.4 Diesel Generators/ Turbines [wrap] <input type="checkbox"/> 3.5 Pumps [wrap] <input type="checkbox"/> 3.6 Fans [wrap] <input type="checkbox"/> 3.7 Rotary Compressors [wrap] <input type="checkbox"/> 3.8 Centrifuges [wrap] <input type="checkbox"/> 3.9 Drills/Rotary Sanders [wrap] <input type="checkbox"/> 3.10 Grinders [wrap] <input type="checkbox"/> 3.11 Other Circular Motion <input type="checkbox"/> 4 Other ME Hazards	<input type="checkbox"/> 1 Flammable Gases <input type="checkbox"/> 1.1 Natural Gas/Propane <input checked="" type="checkbox"/> 1.2 Welding/Cutting Gases <input type="checkbox"/> 1.3 Laboratory/Calibration Gases <input type="checkbox"/> 1.3.1 Methane/Butane <input type="checkbox"/> 1.3.2 H ₂ [lab] <input type="checkbox"/> 1.4 Process/Reaction Off-Gases <input checked="" type="checkbox"/> 1.4.1 H ₂ [containers] <input type="checkbox"/> 1.4.2 H ₂ [process] <input type="checkbox"/> 1.4.3 Sewer Gas <input type="checkbox"/> 1.4.4 Carbon Monoxide <input type="checkbox"/> 1.5 Other Flammable Gases <input type="checkbox"/> 2 Flammable/Combustible Liquids <input type="checkbox"/> 2.1 HEPA Test Aerosol Fluid <input type="checkbox"/> 2.2 Petroleum Based Products <input checked="" type="checkbox"/> 2.2.1 Gasoline <input checked="" type="checkbox"/> 2.2.2 Diesel Fuel <input checked="" type="checkbox"/> 2.2.3 Oils [lube, coolant] <input checked="" type="checkbox"/> 2.2.4 Grease <input checked="" type="checkbox"/> 2.3 Vehicle/Equipment Fuel Tanks <input checked="" type="checkbox"/> 2.3.1 Gasoline [tank] <input checked="" type="checkbox"/> 2.3.2 Diesel Fuel [tank] <input checked="" type="checkbox"/> 2.4 Paint/Cleaning/ Decontamination Solvents <input type="checkbox"/> 2.5 Paints/Epoxies/Resins <input type="checkbox"/> 2.6 Other Flammable Liquids <input checked="" type="checkbox"/> 3 Combustible Solids <input checked="" type="checkbox"/> 3.1 Paper/Wood Products <input checked="" type="checkbox"/> 3.2 Cloth/Rags <input checked="" type="checkbox"/> 3.3 Rubber <input checked="" type="checkbox"/> 3.4 Plastic Materials <input type="checkbox"/> 3.4.1 Size Reduction Tents/ Permacons <input type="checkbox"/> 3.4.2 Benelex/Lexan/HDPE <input type="checkbox"/> 3.4.3 Rigid Liners/Poly-Liners/ Bagging Materials <input type="checkbox"/> 3.5 Other Combustible Solids	<input type="checkbox"/> 1 High Voltage Equipment <input type="checkbox"/> 1.1 Power Transmission Equipment <input type="checkbox"/> 1.1.1 Wiring [high voltage] <input checked="" type="checkbox"/> 1.1.2 Overhead Transmission Lines <input type="checkbox"/> 1.1.3 Transformers [high voltage] <input type="checkbox"/> 1.1.4 Switchgear [high voltage] <input type="checkbox"/> 1.2 Capacitor Banks <input type="checkbox"/> 1.3 Lightning Grids <input type="checkbox"/> 1.4 Other High Voltage Hazards <input type="checkbox"/> 2 Low Voltage Equipment <input checked="" type="checkbox"/> 2.1 480/240/120 Volt Equipment <input type="checkbox"/> 2.1.1 Wiring [low voltage] <input type="checkbox"/> 2.1.2 Cable Runs <input type="checkbox"/> 2.1.3 Overhead Wiring <input type="checkbox"/> 2.1.4 Underground Wiring <input type="checkbox"/> 2.1.5 Transformers [low voltage] <input type="checkbox"/> 2.1.6 Switchgear [low voltage] <input type="checkbox"/> 2.1.7 Service Outlets <input type="checkbox"/> 2.1.8 Other Electrical Equipment <input checked="" type="checkbox"/> 2.2 Temporary Power Equipment <input checked="" type="checkbox"/> 2.2.1 Diesel Units <input type="checkbox"/> 2.2.2 Battery Banks <input type="checkbox"/> 2.2.3 12-32 V DC Systems <input type="checkbox"/> 2.2.4 Other Temporary Electrical <input checked="" type="checkbox"/> 2.3 Electrical Equipment [low voltage] <input checked="" type="checkbox"/> 2.3.1 Motors <input type="checkbox"/> 2.3.2 Pumps <input checked="" type="checkbox"/> 2.3.3 Fans <input checked="" type="checkbox"/> 2.3.4 Compressors <input checked="" type="checkbox"/> 2.3.5 Heaters <input type="checkbox"/> 2.3.6 Valves/Dampers <input checked="" type="checkbox"/> 2.3.7 Power Tools <input checked="" type="checkbox"/> 2.3.8 Instrumentation <input type="checkbox"/> 2.3.9 Other Electrical Use Equipment <input type="checkbox"/> 2.4 Grounding Grids <input type="checkbox"/> 2.5 Static Charge <input type="checkbox"/> 2.6 Other Low Voltage Hazards

Table A-2. Hazard Identification Checklist and Energy Designators for 618-10 and 618-11 Waste Sites. (5 sheets)

RE Radiant Energy	RM Radioactive Material	TE Thermal Energy
<input type="checkbox"/> 1 Direct Radiation Sources	X 1 Fissile Material [Metals/Oxides/Residues]	X 1 Chemical Reactions
<input type="checkbox"/> 1.1 Calibration Sources	<input type="checkbox"/> 1.1 Bag	X 2 Pyrophoric Material
<input type="checkbox"/> 1.2 Other Radioactive Material	<input type="checkbox"/> 1.2 Glovebox [exposed]	X 2.1 Plutonium/Uranium Metal
<input type="checkbox"/> 1.2.1 Fissile Material Storage/ Holdup	X 1.3 Can	X 2.2 Pyrophoric Chemicals
<input type="checkbox"/> 1.2.2 Actinide Solutions	X 1.4 Welded Can	<input type="checkbox"/> 2.3 Other Pyrophoric Material
X 1.2.3 Waste Containers	X 1.5 Drum	X 3 Spontaneous Combustion Material
X 1.2.4 Contamination	X 1.6 Overpack	X 3.1 Petroleum Based Products
<input type="checkbox"/> 1.3 Other Direct Radiation Hazards	<input type="checkbox"/> 1.7 Type B Shipping Container	X 3.2 Reactive Chemicals
X 2 Ionizing Radiation Devices	<input type="checkbox"/> 1.8 Ducting [exposed]	X 3.3 Nitric Acids/Organics
X 2.1 Radiography Equipment	<input type="checkbox"/> 1.9 Plenum [exposed]	X 3.4 Paint/Cleaning/ Decontamination Solvents
<input type="checkbox"/> 2.2 X-Ray Machines	X 1.10 Filter [exposed]	<input type="checkbox"/> 4 Open Flame Sources
<input type="checkbox"/> 2.3 Electron Beams	<input type="checkbox"/> 1.11 Cooler	<input type="checkbox"/> 4.1 Cutting Torches
<input type="checkbox"/> 2.4 Ultra-Intense Lasers	X 1.12 Hood [exposed]	X 4.2 Welding Torches
<input type="checkbox"/> 2.5 Accelerators	<input type="checkbox"/> 1.13 Other Solid Fissile Material	<input type="checkbox"/> 4.3 Laboratory Burners
<input type="checkbox"/> 2.6 Other Ionizing Hazards	X 2 Actinide Solution	<input type="checkbox"/> 4.4 Other Open Flames
<input type="checkbox"/> 3 Non-Ionizing Radiation Sources	X 2.1 Bottle	X 5 Heating Devices/Systems
<input type="checkbox"/> 3.1 Electromagnetic Sources	X 2.2 Drum	<input type="checkbox"/> 5.1 Furnaces
<input type="checkbox"/> 3.1.1 Electromagnetic Communication Waves	<input type="checkbox"/> 2.3 Piping	<input type="checkbox"/> 5.2 Boilers
<input type="checkbox"/> 3.1.2 Radio-Frequency Generators	<input type="checkbox"/> 2.4 Tank	X 5.3 Heaters
X 3.1.3 Microwave Frequencies	<input type="checkbox"/> 2.5 Other Liquid Fissile Material	<input type="checkbox"/> 5.4 Hot Plates
X 3.1.4 Electromagnetic Fields	X 3 Waste [LLW, LLM, TRU, TRM]	<input type="checkbox"/> 5.5 RTGs
<input type="checkbox"/> 3.1.5 Electric Furnaces	X 3.1 Bag	<input type="checkbox"/> 5.6 Other Heating Equipment
<input type="checkbox"/> 3.1.6 Computers	<input type="checkbox"/> 3.2 Glovebox [exposed]	<input type="checkbox"/> 6 Radioactive Decay
<input type="checkbox"/> 3.2 Welding/Cutting Devices	X 3.3 Drum	X 7 High Temperature Items
<input type="checkbox"/> 3.2.1 Plasma Arc Magnetic Field	X 3.4 Metal Crate	X 7.1 Lasers
<input type="checkbox"/> 3.2.2 Plasma Arc Infrared/Ultraviolet Light	X 3.5 Pipe Overpack Container	<input type="checkbox"/> 7.2 Incinerators/Fire Boxes
X 3.2.3 Welding	X 3.6 Overpack	X 7.3 Engine Exhaust Surfaces
<input type="checkbox"/> 3.3 Low Power Lasers	<input type="checkbox"/> 3.7 Shipping Cask	<input type="checkbox"/> 7.4 Steam Lines
<input type="checkbox"/> 3.4 Other Non-Ionizing Hazards	<input type="checkbox"/> 3.8 Ducting [exposed]	X 7.5 Electrical Equipment
<input type="checkbox"/> 4 Potential RE Sources	<input type="checkbox"/> 3.9 Plenum [exposed]	X 7.5.1 Electrical Wiring
X 4.1 Critical Masses	X 3.10 Filter [exposed]	X 7.5.2 Portable Lamps/Lighting
<input type="checkbox"/> 4.1.1 Solid Fissile Material	X 3.11 Hood [exposed]	X 7.6 Welding/Cutting/Grinding Surfaces
<input type="checkbox"/> 4.1.2 Liquid Fissile Material	X 3.12 Wooden Crate	<input type="checkbox"/> 7.6.1 Plasma Arc Surfaces
<input type="checkbox"/> 4.1.3 Containerized Fissile Material	<input type="checkbox"/> 3.13 Cargo Container	X 7.6.2 Welding Surfaces
X 4.2 Irradiated Equipment	X 3.14 Other Waste Material	<input type="checkbox"/> 7.6.3 Grinder/Saw Surfaces
<input type="checkbox"/> 4.3 Other Potential RE Hazards	X 4 General Contamination	X 7.7 Friction Heated Surfaces
<input type="checkbox"/> 5 Other RE Hazards	X 4.1 Contaminated Soils	X 7.7.1 Belts [friction]
	X 4.2 Contaminated Water	X 7.7.2 Bearings [friction]
	X 4.3 Contaminated Oil/Antifreeze	X 7.7.3 Gears [friction]
	X 4.4 Other Contamination	X 7.7.4 Power Tools [friction]
	X 5 Burial Grounds	X 7.7.5 Motors/Fans [friction]
	<input type="checkbox"/> 6 Other RM Hazards	<input type="checkbox"/> 7.8 Other High Temperature Items
		X 8 High Ambient Temperature Areas
		<input type="checkbox"/> 8.1 Loss of Ventilation
		<input type="checkbox"/> 8.2 Areas Around Furnaces/Boilers
		X 8.3 Multiple Layers PPE
		<input type="checkbox"/> 9 Other TE Hazards

Table A-2. Hazard Identification Checklist and Energy Designators for 618-10 and 618-11 Waste Sites. (5 sheets)

PE Potential Energy	PE Potential Energy (cont'd)	PE Potential Energy (cont'd)
<input type="checkbox"/> 1 Pressure-Related PE Hazards X 1.1 Compressed Gases <input type="checkbox"/> 1.1.1 Breathing Air/Compressed Air/O ₂ X 1.1.2 He/Argon/Specialty Gases <input type="checkbox"/> 1.1.3 Refrigerants/CO ₂ Bottles X 1.1.4 Other Bottled Gases <input type="checkbox"/> 1.1.5 Gas/Air Receivers/ Compressors X 1.1.6 Other Compressed Gas <input type="checkbox"/> 1.2 High Pressure Gas Systems <input type="checkbox"/> 1.2.1 Pressure Vessels <input type="checkbox"/> 1.2.2 Instrument/Plant Air <input type="checkbox"/> 1.2.3 Chemical Reaction Vessels/ Autoclaves <input type="checkbox"/> 1.2.4 Furnaces/Boilers <input type="checkbox"/> 1.2.5 Steam Header/Lines <input type="checkbox"/> 1.2.6 Pneumatic Lines <input type="checkbox"/> 1.2.7 Impact Tools <input type="checkbox"/> 1.2.8 Sand/CO ₂ Blasting Equipment <input type="checkbox"/> 1.2.9 Other Pressurized Gas <input type="checkbox"/> 1.3 High Pressure Liquid Systems <input type="checkbox"/> 1.3.1 Water Heaters <input type="checkbox"/> 1.3.2 Excavators/Backhoes [hydraulics] <input type="checkbox"/> 1.3.3 Cranes [hydraulics] X 1.3.4 Trucks/Cars [hydraulics] X 1.3.5 Forklifts [hydraulics] <input type="checkbox"/> 1.3.6 Conveyors [hydraulics] <input type="checkbox"/> 1.3.7 Hydrolazing Equipment X 1.3.8 Tool Hydraulic Lines <input type="checkbox"/> 1.3.9 Solution Transfer Systems <input type="checkbox"/> 1.3.10 Other Pressurized Liquids <input type="checkbox"/> 1.4 Pressurized Systems/ Components <input type="checkbox"/> 1.4.1 Coiled Springs <input type="checkbox"/> 1.4.2 Stressed Members <input type="checkbox"/> 1.4.3 Torqued Bolts <input type="checkbox"/> 1.4.4 Gaskets/Seals/O-Rings X 1.4.5 Fire Suppression Systems <input type="checkbox"/> 1.4.6 Other Pressurized Systems <input type="checkbox"/> 1.5 Vacuum Systems <input type="checkbox"/> 1.6 Other Pressure PE Hazards	<input type="checkbox"/> 2 Gravity-Related PE Hazards <input type="checkbox"/> 2.1 Elevated Equipment/Structures <input type="checkbox"/> 2.1.1 Cranes/Hoists <input type="checkbox"/> 2.1.2 Ducting/Lights/Piping <input type="checkbox"/> 2.1.3 Rollup Doors <input type="checkbox"/> 2.1.4 Elevators <input type="checkbox"/> 2.1.5 Roofs/Plenums <input type="checkbox"/> 2.1.6 Upper Floor Components <input type="checkbox"/> 2.1.7 Tanks/Solutions in Elevated Equipment <input type="checkbox"/> 2.1.8 Steam/Natural Gas Lines X 2.1.9 Power Lines/ Transformers <input type="checkbox"/> 2.1.10 Other Elevated Equipment <input type="checkbox"/> 2.2 Elevated Hazardous Materials <input type="checkbox"/> 2.2.1 Crane Loads X 2.2.2 Truck Loads <input type="checkbox"/> 2.2.3 Forklift/Other Lifts Loads <input type="checkbox"/> 2.2.4 Conveyor Loads <input type="checkbox"/> 2.2.5 Hoist Loads <input type="checkbox"/> 2.2.6 Cart Loads <input type="checkbox"/> 2.2.7 Hand Carried Loads <input type="checkbox"/> 2.2.8 Stacked Hazardous Materials <input type="checkbox"/> 2.2.9 Other Elevated Materials X 2.3 Pits/Trenches/ Excavations <input type="checkbox"/> 2.4 Elevated Work Surfaces <input type="checkbox"/> 2.4.1 Roofs/Elevated Doors/Loading Docks <input type="checkbox"/> 2.4.2 Stairs/Elevators <input type="checkbox"/> 2.4.3 Ladders/Fixed Ladders <input type="checkbox"/> 2.4.4 Cherry-Pickers/Hysters <input type="checkbox"/> 2.4.5 Scaffolding/Scissor Jack Scaffolds <input type="checkbox"/> 2.4.6 Other Elevated Surfaces <input type="checkbox"/> 2.5 Other Gravity PE Hazards	<input type="checkbox"/> 3 Momentum-Related PE Hazards X 3.1 Moving Vehicle/Transport Devices <input type="checkbox"/> 3.1.1 Rail Cars/Trains [in motion] <input type="checkbox"/> 3.1.2 Cranes [in motion] X 3.1.3 Trucks [in motion] <input type="checkbox"/> 3.1.4 Forklifts/Loaders [in motion] <input type="checkbox"/> 3.1.5 Other Moving Materials <input type="checkbox"/> 3.2 Rotating Equipment <input type="checkbox"/> 3.2.1 Bearings/Rollers/Shafts X 3.2.2 Gears/Couplings/Pivot Joints X 3.2.3 Diesel Generators/Turbines <input type="checkbox"/> 3.2.4 Pumps <input type="checkbox"/> 3.2.5 Fans/Air Movers <input type="checkbox"/> 3.2.6 Rotary Compressors <input type="checkbox"/> 3.2.7 Centrifuges <input type="checkbox"/> 3.2.8 Other Rotating Equipment <input type="checkbox"/> 3.3 Other Momentum PE Hazards <input type="checkbox"/> 4 Other PE Hazards

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APPENDIX D
COMPUTER-GENERATED INPUT AND OUTPUT

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APPENDIX D

COMPUTER-GENERATED INPUT AND OUTPUT

Appendix D contains the input and output files for the atmospheric dispersion coefficient calculations performed using the GXQ code. GXQ performs an interpolation of measured atmospheric data to determine bounding conditions. The calculation is discussed in Section 3.4. WHC-SD-GN-SWD-30002, *GXQ 4.0 Program Users' Guide*, Rev. 1, should be consulted for a detailed explanation of the code methods and the variables used in the input and output.

```

618 -11 waste site 95% river bd no BW/No PM
c GXQ Version 4.0 Input File
c mode
  1
c
c MODE CHOICE:
c mode = 1 then X/Q based on Hanford site specific meteorology
c mode = 2 then X/Q based on atmospheric stability class and wind speed
c mode = 3 then X/Q plot file is created
c
c LOGICAL CHOICES:
c ifox inorm icdf ichk isite ipop
  t     f     f     f     t     f
c ifox = t then joint frequency used to compute frequency to exceed X/Q
c      = f then joint frequency used to compute annual average X/Q
c inorm = t then joint frequency data is normalized (as in GENII)
c      = f then joint frequency data is un-normalized
c icdf  = t then cumulative distribution file created (CDF.OUT)
c      = f then no cumulative distribution file created
c ichk  = t then X/Q parameter print option turned on
c      = f then no parameter print
c isite = t then X/Q based on joint frequency data for all 16 sectors
c      = t then X/Q based on joint frequency data of individual sectors
c ipop  = t then X/Q is population weighted
c      = f then no population weighting
c
c X/Q AND WIND SPEED ADJUSTMENT MODELS:
c ipuff idep isrc iwind
  0     0     0     0
c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:
c iwake ipm iflow ientr
  0     0     0     0
c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:
c (irise igrnd) iwash igrav
  0     0     0     0
c ipuff = 1 then X/Q calculated using puff model
c      = 0 then X/Q calculated using default continuous plume model
c idep  = 1 then plume depletion model turned on (Chamberlain model)
c isrc  = 1 then X/Q multiplied by scalar
c      = 2 then X/Q adjusted by wind speed function
c iwind = 1 then wind speed corrected for plume height
c iwake = 1 then NRC RG 1.145 building wake model turned on
c      = 2 then MACCS virtual distance building wake model turned on

```

```

c ipm   = 1 then NRC RG 1.145 plume meander model turned on
c       = 2 then 5th Power Law plume meander model turned on
c       = 3 then sector average model turned on
c iflow = 1 then sigmas adjusted for volume flow rate
c ientr = 1 then method of Pasquill used to account for entrainment
c irise = 1 then MACCS buoyant plume rise model turned on
c       = 2 then ISC2 momentum/buoyancy plume rise model turned on
c igrnd = 1 then Mills buoyant plume rise modification for ground effects
c iwash = 1 then stack downwash model turned on
c igrav = 1 then gravitational settling model turned on
c       = 0 unless specified otherwise, 0 turns model off
c
c PARAMETER INPUT:
c
c      reference      frequency
c      release      anemometer      mixing      to
c      height      height      height      exceed
c      hs (m)      ha (m)      hm (m)      Cx (%)
c
c      _____      _____      _____      _____
c      0              10              1000              5.0
c
c      initial      initial      release      deposition      gravitational
c      plume      plume      duration      velocity      settling
c      width      height      trd (hr)      velocity      velocity
c      Wb (m)      Hb (m)              vd (m/s)      vg (m/s)
c
c      _____      _____      _____      _____      _____
c      100              0              0              0.00              0.00
c
c      initial      initial      release      convective
c      ambient      plume      plume      heat release
c      temperature      temperature      flow rate      diameter      rate (l)
c      Tamb (C)      T0 (C)      V0 (m3/s)      d (m)      qh (w)
c
c      _____      _____      _____      _____      _____
c      20              20              1              1              0
c
c (1) If zero then buoyant flux based on plume/ambient temperature
difference.
c
c      X/Q      Wind
c      scaling      Speed
c      factor      Exponent
c      c (?)      a (?)
c
c      _____      _____
c      1.00      .78
c
c RECEPTOR DEPENDENT DATA (no line limit)
c FOR MODE      make      RECEPTOR DEPENDENT DATA
c 1 (site specific)      sector distance receptor-height
c 2 (by class & wind speed) class windspeed distance offset receptor-height
c 3 (create plot file)      class windspeed xmax imax ymax jmax xqmin power
c
c RECEPTOR PARAMETER DESCRIPTION
c sector = 0, 1, 2... (all, S, SSW, etc.)
c distance = receptor distance (m)
c receptor height = height of receptor (m)
c class = 1, 2, 3, 4, 5, 6, 7 (P-G stability class A, B, C, D, E, F, G)
c windspeed = anemometer wind speed (m/s)

```

c offset = offset from plume centerline (m)
c xmax = maximum distance to plot or calculate to (m)
c imax = distance intervals
c ymax = maximum offset to plot (m)
c jmax = offset intervals
c xqmin = minimum scaled X/Q to calculate
c power = exponent in power function step size

0	100	0
1	12250	0
2	11860	0
3	11860	0
4	16270	0
5	22260	0
6	35040	0
7	37270	0
8	21630	0
9	10260	0
10	7430	0
11	6240	0
12	5890	0
13	5990	0
14	5580	0
15	6290	0
16	7860	0

Current Input File Name: 618ws.IN

GXQ Version 4.0
December 19, 1994

General Purpose Atmospheric Dispersion Code
Produced by Westinghouse Hanford Company

Users Guide documented in WHC-SD-GN-SWD-30002 Rev. 1.
Validation documented in WHC-SD-GN-SWD-30003 Rev. 1.
Code Custodian is: Brit E. Hey

Westinghouse Hanford Company
P.O. Box 1970
Richland, WA 99352
(509) 376-2921

Run Date = 01/24/03
Run Time = 16:25:08.28

INPUT ECHO:

618 -11 waste site 95% river bd no BW/No PM

c GXQ Version 4.0 Input File

c mode

1

c

c MODE CHOICE:

c mode = 1 then X/Q based on Hanford site specific meteorology

c mode = 2 then X/Q based on atmospheric stability class and wind speed

c mode = 3 then X/Q plot file is created

c

c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop

T F F F T F

c ifox = t then joint frequency used to compute frequency to exceed X/Q

c = f then joint frequency used to compute annual average X/Q

c inorm = t then joint frequency data is normalized (as in GENII)

c = f then joint frequency data is un-normalized

c icdf = t then cumulative distribution file created (CDF.OUT)

c = f then no cumulative distribution file created

c ichk = t then X/Q parameter print option turned on

c = f then no parameter print

c isite = t then X/Q based on joint frequency data for all 16 sectors

c = t then X/Q based on joint frequency data of individual sectors

c ipop = t then X/Q is population weighted

c = f then no population weighting

c

c X/Q AND WIND SPEED ADJUSTMENT MODELS:

c ipuff idep isrc iwind

0 0 0 0

c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:

```

c   iwake ipm   iflow ientr
c     0     0     0     0
c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:
c   (irise igrnd)iwash igrav
c     0     0     0     0
c ipuff = 1 then X/Q calculated using puff model
c       = 0 then X/Q calculated using default continuous plume model
c idep  = 1 then plume depletion model turned on (Chamberlain model)
c isrc  = 1 then X/Q multiplied by scalar
c       = 2 then X/Q adjusted by wind speed function
c iwind = 1 then wind speed corrected for plume height
c iwake = 1 then NRC RG 1.145 building wake model turned on
c       = 2 then MACCS virtual distance building wake model turned on
c ipm   = 1 then NRC RG 1.145 plume meander model turned on
c       = 2 then 5th Power Law plume meander model turned on
c       = 3 then sector average model turned on
c iflow = 1 then sigmas adjusted for volume flow rate
c ientr = 1 then method of Pasquill used to account for entrainment
c irise = 1 then MACCS buoyant plume rise model turned on
c       = 2 then ISC2 momentum/buoyancy plume rise model turned on
c igrnd = 1 then Mills buoyant plume rise modification for ground effects
c iwash = 1 then stack downwash model turned on
c igrav = 1 then gravitational settling model turned on
c       = 0 unless specified otherwise, 0 turns model off
c
c PARAMETER INPUT:
c
c   release          reference          frequency
c   height           anemometer         to
c   hs (m)           height             exceed
c                   ha (m)              Cx (%)
c
c   0.00000E+00      1.00000E+01        1.00000E+03      5.00000E+00
c
c   initial          initial            release          deposition          gravitational
c   plume            plume              duration         velocity           settling
c   width            height             trd (hr)          velocity           velocity
c   Wb (m)           Hb (m)              vd (m/s)         vg (m/s)
c
c   1.00000E+02      0.00000E+00        0.00000E+00      0.00000E+00      0.00000E+00
c
c   ambient          initial            initial          release            convective
c   temperature      plume              plume           diameter          heat release
c   Tamb (C)         temperature         flow rate       d (m)             rate (1)
c                   T0 (C)               V0 (m3/s)      qh (w)
c
c   2.00000E+01      2.00000E+01        1.00000E+00      1.00000E+00      0.00000E+00
c
c (1) If zero then buoyant flux based on plume/ambient temperature
difference.
c
c   X/Q              Wind
c   scaling          Speed
c   factor           Exponent
c   c (?)            a (?)
c
c   1.00000E+00      7.80000E-01

```

```

c
c RECEPTOR DEPENDENT DATA (no line limit)
c FOR MODE      make      RECEPTOR DEPENDENT DATA
c 1 (site specific)      sector distance receptor-height
c 2 (by class & wind speed) class windspeed distance offset receptor-height
c 3 (create plot file)    class windspeed xmax imax ymax jmax xqmin power
c
c RECEPTOR PARAMETER DESCRIPTION
c sector = 0, 1, 2... (all, S, SSW, etc.)
c distance = receptor distance (m)
c receptor height = height of receptor (m)
c class = 1, 2, 3, 4, 5, 6, 7 (P-G stability class A, B, C, D, E, F, G)
c windspeed = anemometer wind speed (m/s)
c offset = offset from plume centerline (m)
c xmax = maximum distance to plot or calculate to (m)
c imax = distance intervals
c ymax = maximum offset to plot (m)
c jmax = offset intervals
c xqmin = minimum scaled X/Q to calculate
c power = exponent in power function step size

```

MODE:

Site specific X/Q calculated.

LOGICAL CHOICES:

Joint frequency used to calculate X/Q based on frequency of exceedance.

No normalization of joint frequency.

X/Q calculated for overall site.

MODELS SELECTED:

Default Gaussian plume model selected.

WARNING/ERROR MESSAGES:

JOINT FREQUENCY DATA:

400 AREA (FFTF) - 10 M - Pasquill A - G (1983 - 1991 Average)

Created 8/26/92 KR

618 -11 waste site 95% river bd no BW/No PM

SECTOR	DISTANCE (m)	RECEPT HEIGHT (m)	SECT. FREQ. (%)	POPULATION	TOTAL POPULATION SCALED X/Q (s/m3)	AVERAGE INDIVIDUAL SCALED X/Q (s/m3)	ATM. STAB. CLASS	WIND SPEED (m/s)
ALL	100	0	99.98	1	3.11E-02	3.11E-02	G	2.65
ALL	7860	0	99.98	1	2.28E-05	2.28E-05	G	4.70